PROCEEDINGS

OF THE

ROYAL SOCIETY OF EDINBURGH.

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Monday, 17*th February* 1862.

PROFESSOR KELLAND, V.P., in the Chair.

The following Communications were read:—

1. On the Condition of the Salmon Fisheries of England and Wales in 1861; with a Notice of some of the Modes of Fishing, especially those practised in the Severn and Wye. By Sir William Jardine, Bart., F.R.S., &c.

The author proposed in this paper to give more detailed observations on the salmon fisheries of England and Wales than could be done in the compass of an official report, and at the same time to add notes on the natural history of the migratory species of Salmonidæ met with in these fisheries. The first part related to the Severn and Wye.

No subject has been more legislated upon than that of the regulation of the salmon fisheries of Great Britain and Ireland; and while this indicates the importance attached to them, it has been at the same time mainly caused by the want of a correct knowledge of the facts relating to them, an ignorance of the habits and natural economy of the species, and by parties looking at one or two insulated points only, instead of viewing the subject and the various interests connected with it as one.

Independently of the want of co-operation by the proprietors of rivers, and the system of killing fish at all seasons of the year, weirs put up for the purpose of driving machinery, and to which fish-traps

were almost always attached, caused great injury and obstruction to the run of salmon; and the Severn had been specially injured by the erection, within a few years, of large weirs for navigation purposes, which not only prevented salmon running freely, but completely prevented access to flounders and all the smaller migratory fish which ascended for the purpose of spawning; such as shad, lamprey, lampern, &c. &c. These all yielded a considerable revenue and food for the population, and were taken 100 miles above tideway. They are all now entirely shut out.

The Severn and Wye have been for a long period, and still continue to be, fished by peculiar engines, which, in all probability, may soon be entirely done away with, or be much modified in structure; a record of these is therefore interesting. Those used in the Severn are putts and putchers, or trumpets, as the latter are termed from their shape; and they form in that river by far the most extensive salmon-fishery by means of fixed engines in any part of the English or Welsh waters.

Putchers or *trumpets* are long, conical, wicker-work baskets with a mouth two feet wide, gradually narrowing, and ending in an opening so small as to prevent a fish of moderate size passing through. This, indeed, is frequently abused, and some are made so small as to take fish of two pounds weight. The stake or framework for these engines is about thirteen or fourteen feet high, and is fixed into the shore in two parallel rows of various lengths from high-water mark seaward. These are bound together by cross bars, on which rest the *putchers*, placed one above another in rows, with the wide mouth up or down stream, as they are intended to catch fish upon the ebb or flow of the tide. The greatest number are set with the mouth up the river, or to the stream; the salmon falling down with the current enter the large mouth, and are literally jammed in the narrow end, which admits the head only, and holds the fish secure. They are thus often much injured, and rendered unseemly for the market by the scales being rubbed off in the struggles to escape, and no unclean, unseasonable, or old fish that enters can again escape or be let out alive. The tide in the Severn rises to a great perpendicular height, often exceeding twenty feet above the top of the putcher stages; and it is considered that comparatively few salmon are taken during the flow, the fish swimming near the surface, and above the mouths of the putchers, as soon as

the tide rises a few feet above them. Most fish are taken in the ebb, or in the putchers with their mouths set up the river, proving without doubt that a large number of fish ascend so far and return again without ever entering the fresh-water part of the river.

The *putts* or *putt-nets*, as they are sometimes called, are placed on the same kind of stages. They are also formed of wicker or basket work, but are more complicated, and the wicker work is closer, and executed with more care. The whole machine is about twelve feet long, and consists of three parts, which can be attached to each other as occasion requires—the kipe, butt, fore-wheel or biddle. The diameter of the chief part, or kipe, is about five feet at the mouth, and fourteen inches at the lower or narrow end. The butt is fourteen inches wide at the neck and six at the lower end. These take large fish by having cross-bars placed in the narrow end; and to this can be affixed at will the third part, the *forewheel* or *biddle*, constructed somewhat like a mouse-trap inside, and used for taking everything small—shrimps, small soles, young cod, flounders, eels, lamperns, &c. In one taken off a few days before, we found shrimps, a small eel, and a rock pipit; in fact, nothing that enters the large, open, five-feet-wide mouth escapes when this fore-wheel is kept attached. The putt-net is extremely destructive to all young fish, and in spring, when the salmon fry descend, they are taken in hundreds. The fishermen, however, say that they now remove the fore-wheel during the fry season, and it is the river conservator's duty to see that this is attended to.

The Wye is a very fine stream, and has also had many persecutions. There are, however, no navigation weirs or other formidable obstructions within the first twenty or twenty-five miles of its course from the sea. One great abuse in this river is the recognised killing of the *skirling*, which is the young of the salmon, the *parr* of Scotch rivers. They are killed in thousands, and are hawked about the country for sale, and purchased by the gentry as well as by the labouring classes. Tourists come to Monmouth to eat skirling. Monmouth is in fact the Woolwich of the Wye; skirling its whitebait. The history and present position of the *parr* question is given here, and is thus summed up. "Any one who will insist now that a parr is not a young salmon, must have some warp in his intellect, not to be removed by any possible demonstration."

In the Wye, coracle nets are much used; but the peculiar mode

of fishing in the Wye, Usk, and that system of rivers, is called *stopping*, or *stop-net fishing*.

At the commencement of the ebb or flow of the tide, a large boat is moored by anchor, and fixed by long sharpened iron-shod poles in what is supposed, or rather by experience is known to be, the "run of the fish." A large bag net, on a frame of from 25 to 35 feet beam, capable of being easily raised by the fishermen employed, is let out upon the side next the ebb or flow, so that the bag is carried out by the tide underneath the boat. The fisherman, with one arm, leans on the angle of the frame ready to act, and has the loop of a cord attached to the bag of the net round a finger of the other hand. The slightest interference with the net is felt by the looped finger, and when a salmon strikes the net is quickly raised, and the fish secured in the bag. At suitable states of the tide, numerous boats may be seen going out prepared to "stop," and ply their precarious fishing. The stations are taken up by turns, some being considered more certain than others, to allow the men an equal chance; for these fishings are generally sublet, the lessee of the fishery sometimes supplying boats and nets, paying the men according to the quantity of fish taken, or a certain agreed upon proportion of the price. It is a mode of fishing, however, far behind the present time and invention, and the boats and nets necessary for it must require very considerable capital. It is, moreover, uncertain, and occupies a large portion of time compared with the quantity of fish taken. There is nothing particularly injurious to the fisheries in the use of these engines if fairly employed, and any unseasonable or old fish may be easily set at liberty uninjured; at the same time, several boats are sometimes set in line, and then they form greater barriers to a clear run; but as it is only for a few hours at the flow of the tide, or after it has partially ebbed, that this kind of fishing can be practised, it can scarcely be looked upon as a serious obstruction.

2. Cases of Poisoning by Goat's Milk. By Alexander E. Mackay, M.D., Surgeon H.M.S. "Marlborough."

On 27th November 1861, eleven wardroom officers of the "Marlborough," including the author, were simultaneously attacked with extreme faintness, nausea, bilious vomiting, and diarrhœa;

the attacks lasting five or six hours—in some of the cases being of great severity, and attended with much depression. The treatment, which was successful in every instance, consisted in encouraging free vomiting, and the administration of stimulants and anodynes. At the same time a series of similar cases occurred in H.M.S. "Agamemnon," and five other ships in the harbour. The only article of food which had been taken by all those who were affected was the milk used at breakfast, and to this the poisoning was evidently to be ascribed. On inquiry amongst Maltese of all classes the author found that there is a plant known in Malta by the name of Tenhuta which is eagerly eaten by the goats, from which animals almost all the milk used by the shipping is procured, and which communicates to their milk nauseous properties. This proved to be *Euphorbia Paralias*, the common sea spurge; and its property of rendering the goat's milk poisonous is so well known, that the goats, from which milk is to be got for supplying families and public institutions in Malta, are never allowed to feed at large where they can have access to the Euphorbia. It was stated to the author that the Maltese milkmen know perfectly well when a goat has eaten the Tenhuta from the appearance of the milk, which, if poured into the hollow of the hand and spread out by the finger, shows yellowish streaks through it. A somewhat puzzling circumstance was, that all the officers who partook of the milk did not suffer, and one gentleman escaped without any seizure who had drunk a whole bottle of milk. On the other hand, of the patients in the sick bay only one was seized, and this was a man who had procured some milk for himself from shore; and one alarmingly severe case, which occurred in the "Agamemnon," was in the person of a gentleman who had breakfasted entirely on milk. The author suggests, as an explanation of the immunity of some and the severe seizures of others of the consumers of the milk, that if the poisonous property reside in the above mentioned yellowish streaks, which seem readily separable from the bulk of the milk, the unequal distribution of the poisonous matter may account for the violent symptoms in one, the milder seizures in a second, and the total absence of all symptoms in a third.

3. Note on the Electricity developed during Evaporation and during Effervescence from Chemical Action. By Professor Tait and J. A. Wanklyn, Esq.

One of Professor W. Thomson's Divided-Ring Electrometers having been recently procured for the Natural Philosophy collection in the University, we have made use of it in repeating and extending the experiments of Volta, Pouillet, and others, on the electricity produced during the evaporation of various bodies. In some cases our results agree with those already known, but in others we find effects differing totally in kind or degree from the accepted ones; and with some substances we find occasionally contradictory indications among our own results.

The Electrometer is in every respect a far superior instrument to the gold-leaf electroscope, which (sometimes with the addition of a condenser) was used by former experimenters, and enables us to give our results in a form easily reducible to absolute measure. The charge of the instrument was such that, when the half rings were respectively connected with the zinc and platinum of a single Grove's cell, the deflection observed amounted to about 5·8 scale divisions. This was found to be the most useful charge for the bulk of our experiments, but it was easily increased twenty or thirty fold when we sought to verify any very delicate indications.

Our apparatus consisted of a platinum dish, placed on an insulating stand, and connected with the insulated half ring. A lamp could be placed on the stand so as to heat the dish; and while this was going on the indications of the electrometer gave us the atmospheric charge. The experiments were all conducted when the latter was very small, so that although the sputtering of the fluids dropped on the hot plate may have prevented us from observing some slight effects, the large deflections we observed in many instances can have nothing to do with the electric state of the air of the room. With a different disposition, which enabled us to use a Bunsen lamp to heat the dish, we obtained the atmospheric potential by burning a little ether or alcohol on the dish itself, when the lamp was removed.

We agree generally with previous experimenters, that during the continuance of the spheroidal state, there is little, if any, perceptible

disengagement of electricity. We also agree with the statement that the main effect is produced while the fizzing sound that accompanies the loss of the spheroidal state is heard, and that during the continuance of the mechanical action to which that sound is due, the indications of the electrometer in general steadily increase. That the greater part of the electricity produced is due to friction is proved by the fact that, when fluids are forcibly squirted upon the hot dish, the electrical indications are very much increased, and that a concave surface gives far more powerful deflections than a convex one at the same temperature. The sputtering or violent boiling which succeeds the fizzing state, shows little, if any, disengagement of electricity. The principal interest of the results which we have obtained is in the cases of iodine, bromine, and various other bodies which do not seem to have been before examined. We have as yet met with no discordance in our own results as far as *simple* bodies are concerned.

In giving the following numbers, we have not attempted any correction for the loss of electricity which is caused by the high temperature of the platinum dish.

Mean Electric Effects given by a few substances during the continuance of the fizzing sound which immediately follows the disappearance of the Spheroidal State, 5·8 representing the Electromotive Force of a Single Grove's Element.

Bromine,	+ 400
Iodine,	+ 90*
Bromide of Ethyl,	+ but very small indeed, if any
Iodide of Methyl,	In many experiments strong +, but in three cases pretty strong −
Benzole,	No effect
Valerianic Ether,	No effect
Common Ether,	Very slight and dubious effects
Chloroform,	− if plate very hot, + if colder
Ammonia,	− 200
Alcohol,	− 10
Mercury,	− 75
Chloride of Sulphur,	− 100
Water (distilled), containing only a trace of carbonic acid, which was too small to be detected by lime-water,	− 80

* This sample was in fine crystals. Far higher effects (also positive) were obtained from it in powder.

Solutions in Water of—	
Carbonate of Potash (strong),	− 310
Caustic Soda (strong), .	− 40 *
Do. (dilute), .	− 25 *
Caustic Potash (combustion strength), . .	+ 150
Nitric Acid (strong), .	+ 7·5
Do. (1 in 4 of water),	− 35
Hydrochloric Acid (strong),	− 160
Do. (weak),	− 50
Sulphuric Acid (strong),	+ 15
Strong solution of Na Cl .	− 400
Do. KI .	− 80
Do. CuO,SO_3	− 1000?
Solution of double Oxalate of Chromium and Potash,	Very trifling effect
$Fe_2 Cl_3$, solution moderate,	Negative effect
Acetic Acid (Monohydrate),	+ 3
Acetic Anhydride, .	− 9

The sulphate of copper solution is by far the most remarkable that we have tried. The smallest globule, on leaving the spheroidal state, gave intense effects, sending the lamp image entirely off the scale.

We have also commenced a set of experiments with a view to test the electricity developed during the brisk disengagement of a gas by chemical action, which was discovered eighty years ago by Volta. In some of these experiments it was observed that when the gases were disengaged with considerable effervescence, and in a mass of large bubbles foaming over the platinum crucible in which the experiment was conducted, the bursting of each bubble was attended by a simultaneous increase of deflection in the electrometer. These experiments are, as yet, exceedingly imperfect, but they seem, like the preceding, to indicate friction as a main cause of the observed results. The effects on the electrometer are by no means so uniform, either as to kind or quantity of electricity, as those given by evaporation.

Electricity developed during Effervescence.

$Zn + HCl$ . .	− 750
$Zn + NO_5HO$.	+ 175. In another trial − 120
$MnO_2 + HCl$ . .	− 150
$CaO,CO_2 + HCl$ . .	Trifling effects
$NaO,SO_2 + HCl$ . .	At first a small negative deflection, finally + 50
$NaCl + SO_3HO$.	+ 10

* This is a very difficult substance to experiment upon.

The following gentlemen were elected Ordinary Fellows:—

THOMAS C. ARCHER, Esq.
Rev. V. G. FAITHFULL.
JAMES HECTOR, M.D.

The following Donations to the Library were announced:—

Manual of Civil Engineering. By William John Macquorn Rankine. 8vo. 1862.—*From the Author.*

Proceedings of the Royal Horticultural Society. Vol. II. No. 2. 8vo.—*From the Society.*

List of the Fellows of the Royal Horticultural Society, corrected to January 1862. 8vo.— *From the Society.*

Proceedings of the Royal Society of London. Vol. XI. No. 47. 8vo.—*From the Society.*

Journal of the Chemical Society. Vol. XV. No. 1. 8vo.—*From the Society.*

Journal of the Royal Dublin Society. Nos. XX.–XXIII. 8vo.—*From the Society.*

Monthly Notices of the Royal Astronomical Society. Vol. XXII. No. 3. 8vo.—*From the Society.*

Abstracts of the Proceedings of the Geological Society of London. No. 75. 8vo.—*From the Society.*

Öfversight af Kongl. Vetenskaps-Akademiens förhandlingar. 1860. 4to.—*From the Royal Academy of Sciences, Stockholm.*

Kongliga Svenska Vetenskaps-Akademiens handlingar. 1859. 4to. —*From the same.*

Kongliga Svenska Fregatten Eugenies Resta omkring Jorden under befäl af C. A. Virgin 'aren 1851–53. Botanik Haft II., Part 2. Zoologi Haft X., Part 5. Fysik Haft VIII., Part 2. 4to.—*From the same.*

Voyage autour du monde sur la Fregate Suedoise l'Eugenie, executé pendant les années 1851–52. Physique Haft IX., Part 2.—*From the same.*

Om fisk-faunan och fiskierna i Norbottens Län Reseberattelse. Af H. Widegren, Afgifvenden 10 Mars. 1860. 8vo.—*From the same.*

Atti del Reale Istituto Lombardo di Scienze, Lettere ed Arti. Vol. II. Fasc. X.–XIV. 4to.—*From the same.*

Memorie del Reale Istituto Lombardo di Scienze Lettere ed Arti. Vol. VIII. Fasc. V. 4to.—*From the same.*

Bulletin de l'Academie Imperiale des Sciences de St Petersbourg. Tom. III. Nos. 6–8. Tome IV. Nos. 1, 2. 4to.—*From the Academy.*

Memoires de l'Academie Imperiale des Sciences de St Petersbourg. VII^{e}. Serie. Tome III. Nos. 10–12. 4to.—*From the same.*

Preisschriften gekrönt und herausgegeben von der fürstlich Jablonowskischen Gesellschaft zu Leipzig. Parts VIII. and X. 1861. 8vo.—*From the same.*

Monday, 3*d March* 1862.

DR CHRISTISON, V.P., in the Chair.

1. On the Pressure Cavities in Topaz, Beryl, and Diamond, and their bearing on Geological Theories. By Sir David Brewster, K.H.

In this paper the author gave a brief account of the various phenomena of fluid and gaseous cavities which he had discovered in diamond, topaz, beryl, and other minerals. He described—

1. Cavities with two immiscible fluids, the most expansible of which has received the name of *Brewstolyne*, and the most dense that of *Cryptolyne*, from the American and French mineralogists.

2. Cavities containing only one of these fluids.

3. Cavities containing the two fluids, and also crystals of various primitive forms, some of which melt by heat and recrystallise in cooling.

4. Cavities containing gas and vapour.

The author stated that the first class of cavities existed in thousands, forming strata plane and curved, and intersecting one another at various angles, but having no relation to the primitive and secondary planes of the crystal. From these facts he drew the conclusion that the minerals which contained them were of igneous origin; and he considered this conclusion as demonstrated by the existence of what he calls *pressure cavities*, which are never found in crystals of aqueous origin. These microscopic cavities, which are numerous in diamond, exist also in topaz and beryl. The gas which filled

them had compressed by its elastic force the substance of the mineral around the cavities, as shown by four sectors or quadrants of light which it polarises; and consequently the mineral must have been in a soft or plastic state by fusion when it thus yielded to the pressure of the included gas.

2. On the Anatomical Relations of the Surfaces of the Tentorium to the Cerebrum and Cerebellum in Man and the lower Mammals. By William Turner, M.B. (Lond.), Senior Demonstrator of Anatomy in the University of Edinburgh.

Comparative anatomists have of late directed considerable attention to the determination of the relations of the cerebrum and cerebellum. This has been in great measure due to the publication by Professor Owen of a system of classification of the Mammalia founded on their cerebral characters. The statement made by that eminent anatomist, that the posterior, or third, lobe of the cerebrum is peculiar and common to the genus Homo, and that equally peculiar are the "posterior horn of the lateral ventricle" and the "hippo-campus minor," which characterise the hind lobe, has led to much discussion. Various anatomists have published descriptions and drawings of dissections of the brains of many of the Quadrumana, especially of several of the higher apes. From these dissections, as well as from the older observations of Tiedemann and Cuvier, it may now be considered as fully proven, that in the Quadrumana the surface of the cerebellum corresponding to the superior surface of the human cerebellum is covered by the cerebrum; that posterior lobes, posterior cornua and hippocampi minores, are possessed by these animals.*

In the mammalia lower in the scale than the Quadrumana, it appears to be the general opinion of anatomists that the posterior cerebral lobes do not exist, and that, from this circumstance, there is always a greater or less amount of cerebellum projecting behind the

* See Professor Huxley, Dr Allen Thomson, Dr Rolleston, and Mr Marshall, in vol. i. of "Natural History Review," 1861; Professors Van der Kolk and Vrolik in January No. for 1862; Professor Huxley, "Proceedings Zoological Society," 1861; Mr Flower, "Proceedings Royal Society of London," 20th June 1861, and 9th January 1862.

cerebrum, and uncovered by it. Tiedemann* has, however, made an exception in favour of the seal, in which animal he says posterior lobes occur, although shorter than in the Simiæ. Cuvier† also recognises the exceptional arrangement in the seal, and places along with it the otter and the dolphins. Retzius‡ states, that in the mammalia lower than man, posterior lobes are found only in the apes, and that rudiments only are met with in the Cetacea and seals.

In the course of a series of observations which I have been making for some time back, on the crania of different mammals, my attention has been especially directed to the relative positions of the cerebrum and cerebellum. These observations have led me to come to the conclusion, that considerable misconception exists as to the relations of the two chief divisions of the encephalon.

If, relying on the published drawings, one may give an opinion of the method of examination of the brain which has been mostly adopted by anatomists, it would appear that the relation of the constituent parts of the brain has been determined after its removal from the cranial cavity, and with its base resting on a flat surface, such as a plate. By a procedure of this kind a very incorrect estimate is formed, for great displacement of parts ensues, especially in the lower mammals. The cerebrum slips forwards, the cerebellum backwards. The medulla, instead of being more or less oblique, is placed horizontally, and causes the cerebellum to be tilted upwards. The arched form of the base is almost entirely destroyed. The displacement is still greater if, at the same time, the membranes are removed.§ The observations which I have conducted have been, for the most part, made without removing the brain from the cavity of the skull. My dissections have been performed chiefly after two methods: 1*st*, By making vertical sections through both skull and brain, immediately on one side of the middle line, so as to preserve uninjured the falx cerebri, and the whole of one lateral half of the organ; 2*d*, By carefully removing with the bone-forceps the pos-

* Icones Cerebri Simiarum, p. 48.

† Leçons d'Anatomie Comparée, vol. iii., 1845.

‡ Müller's Archivs, 1846, p. 154.

§ Mr Marshall, in his description of the brain of a young chimpanzee (Nat. Hist. Rev., vol. i. p. 298), has pointed out very clearly, in the brain of that animal, the changes which ensued after removal from the skull, and immersion for a time in spirit.

terior part of the skull. By this latter method, especially, a view may be obtained of the cerebellum and cerebrum as they lie *in situ*. Owing to the transparency of the dura mater in many of the lower mammals, the relations of these structures to each other may be studied, either with or without the removal of this membrane.

Comparative anatomists, in describing these relations, are in the habit of employing such terms as overlapping, covering, exposure, denudation, to express their extent. Such terms are not, however, sufficiently precise, because they do not convey distinctly which surface of the cerebellum it is which is thus overlapped, covered, exposed, or denuded. Indeed, it is seldom that the attempt has been made, in the lower mammals, to give an accurate definition of these surfaces, so as to distinguish them from each other. Before a close and accurate comparison can be instituted between the relations of the cerebrum to the cerebellum in man and other mammals, it is necessary that such a definition be attempted. It has appeared to me that the septum lying between the cerebrum and cerebellum, commonly termed the tentorium cerebelli, furnishes us with a basis for arriving at a precise conclusion.

If we turn to the descriptions of the cerebellum of man, given in our standard text-books of human descriptive anatomy, we shall find it stated that the cerebellum consists of a central median part—the vermiform process, or worm; and of two lateral lobes—the hemispheres. Of these, the hemispheres preponderate greatly in size. The cerebellum presents an upper and lower surface, and a circumference. The upper surface corresponds to the tentorium cerebelli; the lower is lodged in the concavity of the inferior occipital fossæ, to which it is accurately adapted. The circumference of the cerebellum corresponds to the line of junction of the upper and lower surfaces with each other, and along it a deep fissure, the great horizontal fissure, extends. The circumference—called also the posterior margin—corresponds, therefore, to the line of attachment of the tentorium to the transverse line of the occipital bone, and marks with great precision the divergence of the two surfaces of the cerebellum from each other. Of these surfaces, that which is superior, and in contact with the tentorium, which we may therefore appropriately term tentorial, is the only one related to the cerebrum, the posterior lobes of which not only cover, but even project beyond it. The inferior surface, in contact with the occipital bone,

which may therefore be termed occipital, never possesses any relation whatsoever to the cerebrum.

An examination of several members of most of the great orders of the class Mammalia has satisfied me, that it is quite possible to arrive in them at as correct a conception of the relations of the cerebrum to the cerebellum as in man. In every animal which I have examined, I have found the cerebellum to possess two surfaces. One of these is in contact with the tentorium, and, through the intervention of that membrane, is in relation to the cerebrum. The other is in contact with the wall of the occipital fossa. The surfaces are distinguished from each other by looking in different directions. The tentorial, corresponding to the superior in man, looks, as a rule, more or less forwards. The occipital, corresponding to the inferior in man, looks, as a rule, more or less backwards. These surfaces along their line of junction form an angle, more or less marked in different animals. This angle corresponds to the circumference, or posterior margin, of the human cerebellum, and is in contact with the line of attachment of the tentorium to the occipital bone. The tentorial aspect of the cerebellum, therefore, is that which is in constant relation to the cerebrum, and, not only in man, but in all the mammalia, is covered by it.

That this is the case with regard to the Quadrumana, has been so completely proven by the observations of the various anatomists already referred to, that it appears almost unnecessary to enter again into this question. As I have had an opportunity of dissecting *in situ* the brain of a young and recently dead Cercopithecus, which was given me by my friend Dr M'Bain, I may mention that in it the posterior cerebral lobes not merely covered the tentorial surface of the cerebellum, but projected decidedly beyond its posterior margin. Through the liberality also of Professor Goodsir, I have obtained permission to examine several quadrumanous brains in his possession. All these had been removed from the cranial cavity, and had been lying for some time in spirit.

In a Chimpanzee, the tentorial surface of the cerebellum was directed upwards, and was evidently flatter than the corresponding surface in man. The occipital surface was directed downwards. The posterior margin was clearly marked. The posterior lobes of the cerebrum corresponded to the whole of the tentorial surface, and extended as far as the posterior margin of the cerebellum, beyond

which they might even be stated slightly to project. The inferior vermiform process was lodged in a slight furrow between the two cerebellar hemispheres.

In the brains of several specimens of Cercopitheci, the tentorial and occipital surfaces, with the posterior margin of the cerebellum, were distinctly marked. In all, the posterior cerebral lobes extended over the tentorial surface as far as the posterior margin. In two of the brains, it might be stated that the cerebral lobes projected backwards beyond that margin. The comparatively greater development of the inferior vermiform process, over the lateral hemispheres of the cerebellum, was indicated by the absence of that fossa between the hemispheres in which it lies in the more highly developed human cerebellum.

In a Macacus, a vertical section through the skull and brain of which animal I examined, the cerebrum corresponded to the tentorial aspect of the cerebellum; the posterior lobes of the one and the superior surface of the other extended as far as the margin of attachment of the tentorium to the transverse line of the occiput.

In two specimens of Cynocephali, the same relation of the posterior lobes of the cerebrum to the tentorial aspect of the cerebellum was observed. In neither of these brains was the inferior vermiform process lodged in a depression between the hemispheres, but formed an almost continuous surface with them.*

In three brains, from animals of the genus Ateles, the posterior cerebral lobes extended quite up to the posterior margin, separating the tentorial from the occipital surface of the cerebellum. In all the lateral hemispheres projected slightly beyond the inferior vermiform process, which was lodged in a shallow depression between them.

In a lion monkey (*Midas leoninus*) the occipital surface of the cerebellum was separated from the tentorial by a very clearly defined

* Since this paper was read before the Society, I have dissected *in situ* the brain of a young Shacma, and have found that the cerebrum projected beyond the cerebellum, both laterally and posteriorly. The vermiform process protruded slightly beyond the cerebellar hemispheres. The projection of the cerebral hemispheres backwards beyond the worm was rather less than $\frac{3}{10}$ths of an inch, whilst on each side of the worm it extended to rather more than $\frac{3}{10}$ths of an inch behind the cerebellar hemispheres. The cerebellar and posterior cerebral fossæ in the cranium exhibited an arrangement in conformity with this disposition of the encephalon. (*March 27th.*)

posterior margin, as far as which the posterior cerebral lobes extended. The inferior vermiform process projected beyond the cerebellar hemispheres, which were comparatively feebly developed.

The Cetacea possess, not only in their great mass of brain, but in the number and complexity of the convolutions of their hemispheres, very decided evidences of a high degree of cerebral organisation. Professor Goodsir has allowed me to examine the brains of a porpoise, a bottle-nosed dolphin (*D. Tursio*), and a rorqual (*Balænoptera*), either in his possession, or in the Anatomical Museum. In all, in accordance with the peculiar antero-posterior compression of the cranial cavity, the corresponding diameter of the cerebral hemispheres was very much shortened, so that the brain was widened out, and heightened greatly in its vertical diameter. In all, the distinction between the tentorial and occipital surfaces of the cerebellum was very clearly marked. The cerebrum passed backwards as far as the posterior margin of the cerebellum. The cerebellum in them was a cerebellum inferius; for, as far as could be judged from an inspection of the brains, as they lay out of their cavities, the cerebellum was not exposed when looked at from above. The cerebrum possessed very decided posterior lobes; for, on account of the great extent of the tentorial surface of the cerebellum, and the heaping up of the cerebral convolutions in the vertical diameter, a large proportion of the cerebral hemispheres was placed above the cerebellum.* The brain of the bottle-nosed dolphin had been lying for many years in spirit in the Anatomical Museum. A section had been made into the lateral ventricle on the right side, from which it appeared as if there were indications of a prolongation of the ventricle in the direction of the posterior lobe. When the dissection was extended, so as to obtain a more complete view of the arrangement, it was seen that the lateral ventricle was continued backwards and outwards, sweeping along the posterior part of the optic thalamus. It then changed its direction, and passed downwards and forwards, so as to form the inferior horn. At, or about, the spot where this change took place, a recess, extending backwards in the substance of the cerebral mass was met

* Each hemisphere of *Delphinus Tursio*, measured 5 inches and $\frac{6}{10}$ths in its antero-posterior diameter. The cerebrum extended 2 inches and $\frac{4}{10}$ths behind the posterior end of the corpus callosum, the inferior surface of which mass of cerebrum was in relation to the tentorial surface of the cerebellum.

with. This recess, from its position and curvature, must, I think, be regarded as a rudimentary posterior cornu. As the soaking of a brain in spirit, for a series of years, has a tendency to render the examination of the ventricular arrangements more difficult, than would be the case in a recent brain, I hope, in the course of the summer, to supplement this observation, by an examination of the brain of the common porpoise.

In the brains of those Carnivora which I have been able to examine, the cerebellum has been seen to possess tentorial and occipital surfaces, separated by a slight, yet definite, ridge, which corresponded to the line of attachment of the tentorium to the occipital bone. The cerebellum is not, however, so decidedly a "cerebellum inferius" as in the examples already described. The surfaces of the cerebellum consequently look more or less forwards and backwards. Thus, if we look from above upon the brain of a dog or cat, we see the cerebellum projecting slightly behind the cerebrum, or exposed, as it is usually stated. From the description which has been given by Tiedemann* of these relations, not only in the Carnivora, but in the Ruminantia, Solipeds and Pachydermata, it is evident that he considered a portion, at least, of this exposed surface belonged to the anterior aspect of the cerebellum. But if we examine the brain *in situ*, we shall see that the posterior end of the cerebrum passes as far as the posterior margin of the anterior (tentorial) surface of the cerebellum, so as to cover it. The exposed surface is, therefore, the occipital, or that which corresponds to the inferior surface of the human cerebellum. In the dog, both the tentorial and occipital surfaces of the cerebellum are well developed and about equal in extent. The amount of cerebral hemispheres in relation, through the tentorium, to the corresponding cerebellar surface, is therefore considerable, and warrants us, I think, in regarding them as posterior lobes. The lateral ventricles do not possess any proper posterior cornua; but a slight indentation, continuous with the ventricular cavity, in the substance of each posterior lobe, appears to me to present a rudiment of the posterior horn. In the cat, the tentorial is smaller than the occipital surface of the cerebellum, and the extent of cerebrum in relation with it is proportionally smaller than in the dog, so that the size of its posterior lobes is smaller; for the area of

* Anatomie und Bildungs-geschichte des Gehirns, &c. Nürnberg, 1816. P. 147.

the tentorial surface of the cerebellum may be taken as a measure of the amount of the posterior part of the cerebrum by which it is covered. Its lateral ventricles possess no traces of posterior horns.

I have already mentioned that both Tiedemann and Cuvier have noted that the seal possesses more largely developed cerebral hemispheres than the Carnivora generally; and Cuvier places, along with the seal, the otter. I have, as yet, had no opportunity of examining the brains of these animals, but the accompanying casts of the interior of their cranial cavities will give some conception of the relations of the cerebellum and cerebrum.*

In the otter, the cerebrum not merely covered the tentorial aspect of the cerebellum, but even projected beyond it in a very striking manner. Thus, when the brain was looked at from above, no part of the cerebellum was exposed. From the cast, it would appear as if the occipital surface of the cerebellum looked almost directly backwards. The cerebral hemispheres possessed considerable width posteriorly. In the seal, nearly the same relations prevailed as in the otter; the posterior projection of the cerebral hemispheres was more strongly marked laterally than in the middle line. This was due partly to the ossification of the tentorium and falx cerebri, and partly to the posterior cerebral fossæ not passing quite so far back in the middle line as they did somewhat further outwards.

An inspection of the interior of the cavity of a cranium, in my possession, of a walrus (*Trichecus*), an animal closely allied to the seal, led me to suppose that, if a cast of the cavity were taken, relations of a similar nature would be met with. I, accordingly, made such a cast, and found that the cerebral hemispheres projected backwards beyond those of the cerebellum; this projection, as in the seal, and from the same cause, being more strongly marked laterally than in the middle line. The occipital surface of the cerebellum was almost flat, and directed backwards, with but a slight upward inclination. Both the seal and the walrus may be considered to possess brains of large size, so that the cerebellar hemispheres were concealed by the cerebral lobes when the brain was looked at from above. In them as well as in the otter the cerebellum was inferior.

* Most anatomists, I think, will admit that a very correct general conception of these relations may be obtained in those cases where it is difficult to procure the brains themselves, by making casts of the cranial cavity. The accuracy of this method is ensured, even more absolutely, when the tentorium is ossified.

If one might form an opinion, from the casts of the cranial cavities of these animals, of the size of their posterior cerebral lobes, it is not improbable that they might be found to possess indications of posterior horns to the ventricles. I shall certainly avail myself of the first opportunity which may present itself, to inquire into this point. Besides, I find that Tiedemann in his "Icones," p. 19, in a description of the brain of a *Phoca vitulina*, states, "præteræa cornu posterioris vestigium occurrit."

Of the Pachydermata and Ruminantia, I have examined *in situ* the brains of the pig and sheep. In both these animals the tentorial and occipital surfaces of the cerebellum were clearly indicated by the line of attachment of the tentorium to the occipital bone. In both, the cerebral hemispheres extended backwards as far as that line, so that the tentorial surface of the cerebellar hemispheres was completely covered by it. In the pig, the tentorial surface of the cerebellum was larger proportionally than in the sheep, so that the extent of cerebrum in relation to the cerebellum was greater. When the brain of either animal was examined from above, a partial projection of the cerebellum behind the cerebrum might be seen; but the exposed surface was the occipital, and not the tentorial. From an examination of the brains, preserved in spirit, of the Wart-hog (*Phasco-chœres*) and Peccari (*Dycoteles*) in the possession of Professor Goodsir, it would appear, that in them, as in the common pig, the tentorial surface is covered by the cerebrum.

In the Rodentia, Insectivora, Cheiroptera, and Marsupialia, the cerebellum is no longer placed below the cerebrum, but behind it, so that it becomes really a cerebellum posterius. From the statements which have been made in the works of several anatomists of great distinction, it would appear to be their opinion that the cerebrum has, in these orders, so slight a relation to the cerebellum, that the *corpora quadrigemina* are more or less exposed between the two.* From an examination which I have conducted *in situ*, of the brains of several members of these important groups, I think it very doubtful whether such a general statement is correct. Of the Rodentia, I have examined the rabbit, guinea-pig (*Cavia cobaia*), and rat. In all these animals it was quite possible to distinguish a tentorial and occipital surface in the cerebellum. The area of the

* Tiedemann, Anatomie des Gehirns, p. 146; Icones, p. 48. Cruveilhier, Descriptive Anatomy, p. 1013. Stannius, Lehrbuch, pp. 389, 390.

former was small, and possessed a forward direction. The latter was much larger, and at first sight appeared to be the only surface which the cerebellum possessed. It was directed more or less upwards and backwards. The separation between the two surfaces was indicated by a slight ridge which corresponded to the line of attachment of the tentorium to the occipital bone. As far as this line the cerebrum extended posteriorly. The anterior surface of the cerebellum was thus in relation, through the tentorium, with the cerebrum. Owing to the limited area of this surface, the amount of cerebrum in relation to it was necessarily extremely small, and might be considered as little more than the posterior edge of the cerebral hemispheres. Neither in the rabbit nor guinea-pig could the *corpora quadrigemina* be seen, until the cerebral hemispheres were drawn on one side, or the cerebellum pushed back. In the rat, the hemispheres of the cerebrum were in relation to those of the cerebellum; but, in the middle line, owing to their divergence from each other at the posterior end of the great longitudinal fissure, the upper aspect of the *corpora quadrigemina* could be seen. When a bird's-eye view of the brain was made, a large proportion of cerebellum was exposed lying behind the cerebrum, but this exposed surface was the occipital. Tiedemann, in his "Icones," has illustrated the anatomy of the brain of the Rodentia, by figures of the brains of the agouti (*Cavia agouti*), porcupine, and beaver. In every instance he has represented the cerebrum lying so far in front of the cerebellum as not to be in contact with it. Thus, exposure of the *corpora quadrigemina* is occasioned. From my dissections I am satisfied that this mode of depiction does not give a faithful representation of the relation of the structures. The error has evidently arisen from studying the parts after removal from the cavity, and without taking properly into consideration the relations which they bore to each other *in situ*.

Of the Insectivora, I have dissected *in situ* the brains of the mole and hedgehog. Of the Cheiroptera, I have dissected but one species. In these animals the surfaces of the cerebellum had about the same relation, as regards direction and size, as in the Rodentia. In all, the small tentorial surface was in apposition with little more than the posterior edge of the cerebrum. In none of the animals examined could the *corpora quadrigemina* be seen until the cerebral hemispheres were turned on one side.

Of the Edentata and Monotremata I have, as yet, had no opportunity of dissecting any specimens.

Of the Marsupialia, through Professor Goodsir's kindness, I have been enabled to examine two brains of the kangaroo (*Macropus*). Although these brains had been for some time in spirit, and had evidently to some extent lost their original form, yet it was possible to distinguish in them the tentorial and occipital surfaces of the cerebellum, and to note that the cerebrum had to the former a relation corresponding to that which had been noted in the mammals already described. In the kangaroo, therefore, the exposed surface of the cerebellum is the occipital. The *corpora quadrigemina* could not be seen until the cerebral hemispheres were drawn to one side.

(The paper was illustrated by crania, casts, photographs, and drawings. The drawings were made by Dr Henry S. Wilson, and, to ensure accuracy of form, proportion, and relation, their outlines were taken with the assistance of a camera.)

3. On the Connection between Organic Force and Crystalline Force. By H. F. Baxter, Esq.

The following Donations to the Library were announced :—

Neue Denkschriften der allgemeinen schweizerischen Gesellschaft für die gesammten Naturwissenschaften. Zürich. Bänder XVII. und XVIII. 1860–61. 4to.—*From the Society.*

Mittheilungen der naturforschenden Gesellschaft in Bern, aus dem Jahre 1858. No. 408–423, No. 424–439, No. 440–468. 8vo.—*From the Society.*

Verhandlungen der schweizerischen naturforschenden Gesellschaft bei ihrer 43-ten Versammlung in Bern den 2, 3, und 4, August 1858. 8vo.—*From the Society.*

Atti della Società Elvetica delle Scienze Naturali riunita in Lugano nei Giorni 11, 12, e 13 settembre 1860, Sessione 44ª. 8vo.—*From the Society.*

Sitzungsberichte der Wissenschaften zu München, 1861. I. Heft V. 8vo.—*From the Academy.*

The Journal of the Chemical Society. No. LVIII. 1862. 8vo. —*From the Society.*

Journal of the Asiatic Society of Bengal, No. CVIII. 1861. 8vo.—*From the Society.*

The Journal of Agriculture and the Transactions of the Highland and Agricultural Society of Scotland, No. 76. 8vo.—*From the Society.*

Quarterly Return of the Births, Deaths, and Marriages registered in the Divisions, Counties, and Districts of Scotland. No. XXVIII. 8vo. Supplement to the above.—*From the Registrar-General.*

Supplement to the Monthly Returns of the Births, Deaths, and Marriages registered in the eight principal towns of Scotland. Year 1861. 8vo.—*From the same.*

Monthly Return of the Births, Deaths, and Marriages registered in the eight principal towns of Scotland. January 1862. 8vo.—*From the same.*

Illustrations of the genus Carex. By Francis Boott, M.D. Part III. Tab. 311–411. Folio.—*From the Author.*

Monday, 17*th March* 1862.

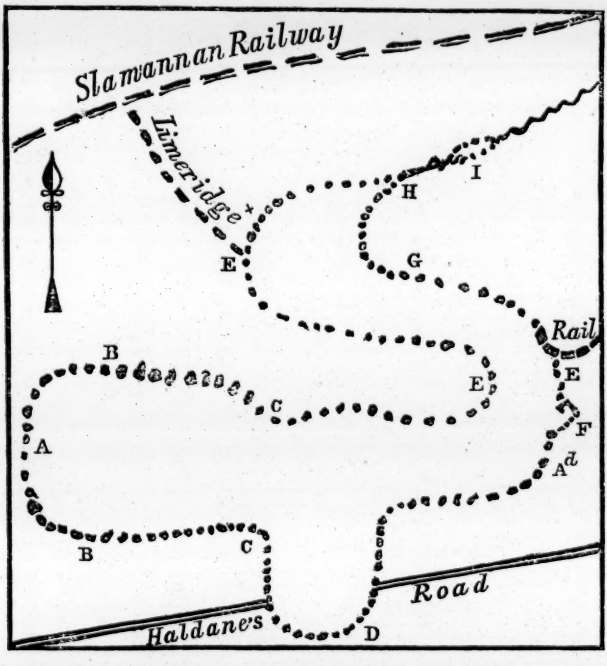
Dr CHRISTISON, V.P., in the Chair.

1. On a recent Landslip. By the Rev. John Duns, Torphichen.

In the introduction to this paper, the author pointed out the prominent physical features of the district in which the landslip occurred. At the point where the trap-ridge, which stretches in a south-west direction from Linlithgow to the neighbourhood of Airdrie, sends one irregular fork to the north-west, and another to the south-west, a broad depression occurs. In this lies the Auchingray moss, the scene of the landslip. Here the parish of New Monkland, Lanarkshire, meets that of Slamannan, Stirlingshire. The following figure is a rough plan of the ground between the Slamannan Railway and Haldane's Moss Road. The area specially influenced by the landslip is enclosed by dotted lines.

The space lying between A and CC, represents the landslip proper. The rest of the ground marked off was that covered by the flow. At present, heath-clad ridges appear at A and BB. These ridges were previously little, if at all, above the level of the moss.

The depression is the result of the immense quantity of soil carried away while the force lasted. Between BB, the centre of the slip, the author on sounding some of the water-filled gaps found them sixteen feet deep.



At A, where the effects of the slip are first seen, the soil has fallen in irregular masses to the east. At the widest part, BB, that lying on the north has given way to the south, and that lying on the south has fallen to the north. The pressure on three sides has been towards the centre, where the depth is greatest. This, the author showed, seemed to indicate, that the force had first become active at that point, and to suggest the explanation of the movement. About forty years ago, the central part was known in the district as the "*blind loch*,"—water covered with reeds, rushes, &c.

The movement of the soil began about seven A.M., 12th August 1861. The author visited the locality a few days later. Heavy rains had fallen for some weeks. August 11th was one of the wettest days of the season, and the wind blew strongly from the west. Great quantities of water had got between the peat and the underlying clay, and had floated the lightest central part. Denser matter would then press in from the sides A and BB, and give greater impetus to the floating mass. The slip, having carried away the

breast-work, would naturally take the direction of least resistance, —viz. the course of the stream which drains the moss.

The area set in motion was estimated at about 300 feet broad at its widest part, BB, and 1320 feet long, from A to A*d*. The slip met with slight elevations at CC; the most formidable of which lying on the north, gave the flow a southerly direction, and led to the deposit of the tongue marked D. Here it spread over portion of a corn field, covered part of the highway, Haldane's Moss Road, and wasted part of a field of turnips lying on the south side of the road.

At the point where the moving material turned to the south, evidences of great disturbance are to be seen. In some cases, huge masses of peat have been turned upside down; and, as they were pushed over sunken portions, their faces now rest on what formerly formed the surface of the ground. On the lumps thus inverted, many branches and roots of native birch trees (*Betula alba*) were to be met with. No birches now grow in the immediate neighbourhood. It was shown that no trees of any sort grew near the moss in 1809; and the birches, it was concluded, had been laid down long anterior to that date. A peculiarity of their roots was pointed out. Many of the main stems, instead of being rounded, have a central depression on both sides, are flat, recurved, and run quickly to a point. Fragments of land shells (Zonites) were picked up among these roots.

At D, the floating material turned again to the north, and bending N. by E., it came in contact with a plantation of Scotch firs. A few of the trees have been carried several yards forward, and now stand as if they had not been moved from their place. Several have been thrust violently, top downwards, into the underlying clay, and others have been placed horizontally on the edges of arrested masses of peat. In its course, much damage was done by the slip to other two corn-fields. At F, it filled a whinstone quarry about fifteen feet deep. At the bend EE, the soil in motion must have been at least twelve feet deep. The great body of the peat, which had been set in motion on the 12th of August, took six days before it reached in bulk the point I, a haugh on each side of Binniehill Burn, where it covered a space described as being as wide as the Clyde near Glasgow. On the 15th, the movement was at the rate of about a yard in two minutes.

A little beyond the neck EE, it met the Limeridge Railway, carried away part of it, and covered it between E and G. It spread over the natural basin marked GG, where it left large masses. One measured seven feet by four feet, and was nearly five feet deep. At H it entered Binniehill Burn, and covered the haugh I. The next point favourable for it spreading occurs in the haugh on the south and east of Slamannan village. At this place it covered the highway at two points, and left about two feet of peat soil on the surface of the clay, at that time under cultivation. Having reached the Avon, the flow left broad marks on its banks, as far down as Linlithgow bridge, thirteen miles distant.

The author, in conclusion, pointed out resemblances between the Auchingray landslip and that of the Solway in 1771, and referred to phenomena associated with the Slip now noticed, fitted to shed light on several questions bearing on the formation of modern strata.

2. On the Rainfall in the Lake District in 1861. With some Observations on the Composition of Rain-Water. By John Davy, M.D., F.R.SS., Lond. and Edin.

This paper consists of two parts. In the first part an account is given of the rain-fall in the Lake District during the year 1861, chiefly remarkable for its great amount (exceeding the average by many inches), and varying in different localities from sixty inches on the skirts of the district, for instance, at Kendal and Mirehouse, the latter four miles northward of Keswick, to 123 and 182 inches; the former, the fall at Grasmere, where approaching the higher mountains, the latter at Seathwaite in Borrowdale, a spot in the midst of them.

In the second part an account is given of the author's observations and experiments on rain, in relation to composition, as examined microscopically and chemically.

The results of both trials seem to prove that rain-water is rarely, if ever pure, and that almost constantly it is the vehicle of saline matter, probably derived from the sea, and of other matter as well as saline, probably derived from the land, especially from our great manufacturing districts, and that in each and every instance, the impregnations it contains are raised and diffused by the winds.

The diffusion of matter thus affected is so strongly marked, that, in the author's opinion, it seems to prove that as there is a circula-

tion of water from the sea to the land, and from the land back to the sea, so there is one of saline matter, tending to prevent the perfect exhaustion of the soil, and to favour the growth of herbage on our downs and fells, and of shrubs and trees, where manure never is, and never has been employed.

Whilst in the economy of nature this diffusion is presumed to act beneficially, on the works of man it seems to act in an opposite manner,—being rather destructive than preservative,—rain promoting the decay of all, or almost all, inanimate objects of a perishable kind exposed to its influence, and this mainly by its saline contents.

3. Observations on the Absorbing Power of the Human Skin. By Murray Thomson, M.D., F.C.S., Lecturer on Chemistry, Edinburgh. Communicated by Dr Douglas Maclagan.

For the last sixty years physiological and other authors have been maintaining two very opposite views in regard to the absorption by the skin of substances dissolved in the water of baths. Some authors holding that such salts as iodide of potassium readily reach the blood through the skin, when applied in the form of a bath containing that salt; while others hold that absorption, under such circumstances, never takes place. Among those who hold the affirmative view, I may mention Braconnot, Madden, O'Henry (fils), Carpenter, Chevallier et Petit; and among those who hold the opposite opinion, Currie, Seguin, Lehmann of Leipzig, Kletzinsky.

This long lasting difference of opinion sufficiently indicates, I think, that the subject is surrounded by difficulties. I do not presume, therefore, that the observations I have made settle the question, they are only intended as a contribution to our knowledge on the subject.

My experiments were all made on my own person at various intervals during the last two years. Six of them were made on as many successive nights, so as to try if frequency of bathing rendered the skin more permeable. The general method of making the trials was this:—Into an ordinary bath, a measured quantity of warm water was let, the temperature of which was recorded. Means were taken to keep the heat constant during the experiment. The temperatures ranged usually from 90° to 98°. The salt to be tried was then dissolved, and mixed with the water. The time in the bath

was noted; it varied from half an hour to one hour and a quarter. The whole body was immersed, excepting the head and neck. All the urine voided in twenty-four hours after each bath was collected and concentrated, then tested for the substances experimented on. Six baths were taken, in which iodide of potassium was dissolved. The quantity of the salt varied from 200 to 1300 grains.

Five baths, in which quantities of ferrocyanide of potassium, varying from 1400 to 5000 grains, were dissolved. Four baths were taken, the water of which was rendered strongly alkaline by soda. The result of these fifteen experiments was, that I could not find that any of the substances in the baths passed through the skin into the blood, so as to be found in the urine; the soda baths did not render it alkaline, nor could I detect the other salts in it; and it is to be noted that the tests for them are extremely delicate.

To compare absorption from a mucous surface with the above, I swallowed several different quantities of iodide and ferrocyanide of potassium, when I found that the smallest amount of the former salt I could take internally, and afterwards detect in the urine, was two grains, and of the latter five grains.

A considerable number of trials were made in which tincture of iodine, and two in which iodine ointment were applied to the skin. Neither in these could I afterwards find iodine in the urine.

The general conclusion which my experiments lead me to are, (1.) That though not denying that absorption by the skin of aqueous solution does take place, yet it seems to be the exception and not the rule. (2.) That medicated warm baths, whether natural or artificial, do not appear to owe any virtue they may have to the substances dissolved in them reaching the blood through the skin. At the same time, as there are other ways by which one can conceive such baths to operate on the system, it is not to be concluded that, because absorption may not take place, such baths are useless as therapeutic agents.

4. On the Constitution of Mannite. By J. A. Wanklyn, Esq., and Dr Erlenmeyer.

Chemists are in the habit of assigning to mannite the formula,

$$C_6H_{14}O_6;$$

but the reasons which have hitherto been given for that formula

seem not very conclusive. By a process of fermentation, alcohol and a number of other compounds of well established composition may be obtained from mannite; but inasmuch as disintegration takes place in this process, the formulæ of the products afford no guide to the constitution of the original body.

Up to the present time no compound of known formula has been got from mannite by other than disintegrating processes.

The uncertainty about the real composition of mannite has finally been illustrated by Berthelot, who in his "Chimie organique fondée sur la Synthèse," has proposed the formula,

$$C_3H_7O_3.$$

Berthelot has supported his view by bringing forward a number of salts of mannite, and has hinted at the possibility of preparing the substance from allyl compounds.

The reaction we have to bring forward in this paper is in contradiction to Berthelot. By distilling mannite with a great excess of strong hydriodic acid, in a stream of carbonic acid gas, it is almost completely resolved into Iodide of Hexyl. The change may be thus represented :—

Mannite.

$$C_6H_8(HO)_6 + 11HI.$$

Iodide of Hexyl.

$$= \overbrace{C_6H_{13}I} + 6H_2O + I_{10}.$$

This reaction is conclusive against Berthelot's formula, for it cannot be maintained that an easy reduction with hydriodic acid would increase the complexity of the carbon molecule. A parallel reaction between glycerine and hydriodic acid was observed by one of us some time ago.*

Glycerine.

$$C_3H_5(HO)_3 + 5HI =$$

Iodide of Propyl.

$$\overbrace{C_3H_7I} + 3H_2O + I_4.$$

We are thus conducted to the result: mannite is the hexatomic alcohol of the C_6 series, or, as we prefer to write, Mannite is

* Erlenmeyer. Zeitschrift für Chemie ü. Pharmacie.

Hexyl-hydride, wherein six atoms of hydrogen have been replaced by six atoms of peroxide of hydrogen.

From the recognised connection subsisting between mannite and the sugars, we may expect that the sugars also belong to the Hexyl-hydride series.

Furthermore, just as glycerine has been got from the Propyl series, so may we hope to get mannite from the Hexyl series. It is our intention to attack this problem. We propose to make $C_6H_8Br_6$, and to endeavour by some means to effect a replacement of the Bromine by peroxide of hydrogen.

We subjoin a slight sketch of a few hexylic compounds. Iodide of hexyl $C_6H_{13}I$. (obtained from mannite), is a colourless liquid, having a smell very like that of iodide of amyl. It is very slowly acted upon by light; sp. gr. = 1·439 at 0° C. Boiling-point about 165° C. It can be distilled without suffering decomposition.

Hexyl-alcohol $C_6H_{13}HO$ may be obtained by decomposing the iodide of hexyl by means of oxide of silver and water. Its smell does not bear the slightest resemblance to that of amyl-alcohol.

Hexylene C_6H_{12} is obtained by digesting iodide of hexyl with alcoholic solution of caustic potash. It is a light oil, smelling like amylene; boiling-point about 69° C. Its vapour-density has been found to be 2·88 and 2·97. The formula C_6H_{12} requires 2·9022. It combines with great violence with bromine, yielding

$$C_6H_{12}Br_2.$$

Hexyl-hydride, C_6H_{14}, may be obtained by decomposing the iodide with zinc in presence of alcohol. It is a light oil, having a very fragrant smell, and not attacked by Bromine at any rate in diffused daylight. In these two particulars it differs widely from hexylene, which has an abominable smell, and which hisses when Bromine is dropped into it. In boiling point there is very little difference between hexylene and hexyl-hydride.

All of these compounds have given satisfactory analyses.

[We intend to publish a full account of the Hexyl-compounds.]

The following Gentleman was admitted an Ordinary Fellow.

Nicholas Alex. Dalzell, Esq., A.M., Conservator of Forests, and Superintendent of the Botanical Garden, Bombay.

The following Donations to the Library were announced :—

History of the University of Edinburgh from the Foundation. By Andrew Dalzel, Professor of Greek. With Memoir of the Author. By Professor Cosmo Innes. Two vols. 1862.—*From Miss Dalzel.*

Reise der österreichischen Fregatte Novara um die Erde in den Jahren 1857–1859, unter den Befehlen des Commodor B. von Wüllerstorf Urbair. Zwei Bänder. 8vo. Wien, 1861.—*From the Austrian Government.*

Verslagen en Mededeelingen der Koninklijke Akademie van Wetenschappen Afdeeling Natuurkunde. Elfde Deel. 8vo. Amsterdam, 1861.—*From the Academy.*

Verslagen en Mededeelingen der Koninklijke Akademie van Wetenschappen Afdeeling Natuurkunde. Twaalfde Deel. 8vo. Amsterdam, 1861.—*From the Academy.*

Jaarbock van der Koninklijke Akademie van Wetenschappen Gevestigt te Amsterdam voor 1860. 8vo.—*From the Academy.*

Verhandelingen der Koninklijke Akademie van Wetenschappen. Negende Deel. Met Platen. 4to. Amsterdam, 1861.—*From the Academy.*

Journal of the Statistical Society of London. Vol. XXV. Part 1. 8vo. March 1862.—*From the Society.*

Journal of the Proceedings of the Linnean Society. Vol. VI. No. 22. March. 8vo.—*From the Society.*

Proceedings of the Royal Horticultural Society. March, 1862. 8vo.—*From the Society.*

Monthly Return of Births, Deaths, and Marriages registered in the eight principal towns of Scotland. February 1862.—*From the Registrar-General.*

On Earth-currents and their connection with the Diurnal Changes of the Horizontal Magnetic Needle. By the Rev. Humphrey Lloyd, D.D., D.C.L., F.R.SS. L. and E., M.R.I.A., &c., Fellow of Trin. Coll. Dublin. From the Transactions of the Royal Irish Academy. 4to. 1862.—*From the Author.*

Monday, 7th April 1862.

The very Rev. DEAN RAMSAY, V.P., in the Chair.

The following Communications were read :—

1. On the Structure of *Lerneopoda Dalmanni*, with Observations on its Larval Form. By Wm. Turner, M.B. (Lond.), and H. S. Wilson, M.D., Demonstrators of Anatomy.

This apparently little known form of parasitic crustacean has been as yet described only by Retzius and Kröyer. It does not appear, up to this time, to have been recognised as a British species. During the present year, many specimens obtained from the nasal cavity of more than one *Rasa batis*, caught by the Newhaven fishermen, have been examined by the authors.

Female.—One of the largest of the Lerneadæ, divided into cephalo-thorax and abdomen by a constricted neck. Cephalo-thorax $\frac{4}{10}$ths of an inch long; it projected almost at a right angle from the anterior end of the abdomen. On its dorsal surface were a pair of 3-jointed hooked antennæ. In front of the antennæ, and close to the anterior end of the head, was the buccal apparatus. Situated in the middle line was a short, conical, retractile snout, which possessed an oral aperture bounded by two fringed lips at its extremity. The structure of these lips, with that of the jaws and palpæ connected to them, was then fully described. On each side of the snout is a short stump-like process—a modified foot. It was segmented, and possessed a bifid, free extremity, the posterior division of which was armed with a terminal hook; the anterior division, much larger than the posterior, was studded with short bristles. Connected to the base of each stump-like process was a segmented palp-like structure, set with three or four conical papillæ at its free end.

Springing from the sides of the cephalo-thorax, immediately in front of the neck, was a pair of elongated cylindrical arms. Each arm ended superiorly in an expanded clasper. The two claspers were in close contact by flattened, opposed surfaces, but not united together. In the concave upper surface of the opposed claspers a cartilaginous-like bar was placed. The authors then described the

structure of the arms and the bar, and the mode of connection of the parasite through these arrangements to the wall of the nasal chamber of the skate. The structure of two bulb-like protuberances from the sides of the cephalo-thorax, immediately in front of the roots of the arms, was then described. These were the eye-like spots of Retzius and Kröyer.

Abdomen $\frac{7}{10}$ths of an inch long, $\frac{4}{10}$ths broad; had an inverted heart-shaped form; imperfectly defined segmented appearance. The fourth segment, the largest, possessed a median slit-like anal aperture, two elongated ova strings, and two posterior abdominal appendages. The arrangement of the intestinal canal, ovaries, and cement organ was then described. The authors then pointed out certain appearances which they considered indicative of the existence of a nervous system.

The authors agreed with Milne-Edwards in thinking that the elongated cephalo-thorax and the posterior abdominal appendages point decidedly to the advisability of separating this animal from the genus lerneopoda. None of the specimens they examined had the male attached, so that they have not examined it. They have seen the larvæ in various stages of development. When free, the larva was $\frac{1}{37}$th of an inch long and $\frac{1}{60}$th of an inch broad; oval when viewed from dorsal surface; profile view showed a convex dorsal and almost flat ventral surface. It possessed a pair of antennæ and two pairs of limbs. Each of the first pair of limbs was bifid, the two branches bearing long hairs at their extremity. Each of the second pair was bifid, the two branches bearing each a spinous hook at its extremity. A remarkable tail-like prolongation, fringed with pinnate hairs, was then described. The curved intestinal canal, the eye spots, and the pigment masses within the visceral chamber, were then adverted to.

2. Memoir of the Life and Writings of Robert Whytt, M.D., Professor of Medicine in the University of Edinburgh, from 1747 to 1766. By William Seller, M.D., F.R.S.E., F.R.C.P.E.

Biography, the author said, had never done sufficient justice to Robert Whytt, while it began already to omit his name. Whytt had commonly been represented as a follower of Stahl; and this

idea, which was without foundation, had probably been a principal cause why his merits had not always been duly recognised.

It was mentioned in the Memoir, that Whytt was born at Edinburgh, September 6, 1714; he was the son of Robert Whytt of Bennochy, a member of the Scottish bar; he was a posthumous child, born six months after his father's death; he was not yet seven years old when he lost his mother; her name was Murray; she was the daughter of Antony Murray of Woodend, in Perthshire. Whytt was sent, when still very young, to the University of St Andrews, where at the early age of sixteen he took the degree of Master of Arts. When fourteen years old he succeeded, by the death of his elder brother, to the family estate. He had two sisters, who were married, and had descendants. In 1730 he repaired to Edinburgh to study medicine; and there is still extant a manuscript book of notes taken by him at that period from the lectures of George Young. After three or four years devoted to medicine at Edinburgh, he proceeded to London, where he became the pupil of Cheselden; thence to Paris, where he studied anatomy under Winslow; and thence to Leyden, where Boerhaave and Albinus were his preceptors. Finally, in 1736, he took the degree of Doctor of Medicine at Rheims. On his return to Scotland the University of St Andrews spontaneously conferred on him the same medical honour. Having become a fellow of the Edinburgh College of Physicians, he commenced practice, and even at so early an age he is said to have had much success. Soon after he married Miss Robertson, who is described as the sister of General Robertson, Governor of New York. By this lady he had two children, who died in infancy. Her death followed soon after. In 1743 he married Louisa Balfour of Pilrig, whose brother afterwards became Professor of Moral Philosophy in the University of Edinburgh. By this lady he had fourteen children, six of whom survived him. His second wife died in 1764, two years before himself. Whytt suffered severely from ill health for fifteen months before his death, which took place, April 15, 1766. A post-mortem examination showed extensive effusion in both cavities of the pleura, some disease in the mucous membrane of the stomach, and concretions in the pancreas.

Whytt's first work, "On the Virtues of Lime-Water and Soap in the cure of Stone," was published in the Edinburgh Medical Essays

for 1743. It subsequently went through several editions, and was translated into French and German. Though time has rendered a great part of this work obsolete, it still merits a distinguishing mark in the history of science, since Dr Black has left it recorded, that it was the controversy between Whytt and Alston respecting the most solvent kind of lime-water, which led him to the examination of calcareous earth, magnesia, the alkalies, and fixed air, whence he obtained conclusions that placed chemistry within a short period of their date on a wholly new and extended footing.

Whytt's next work, published in 1751, "On the Vital and other Involuntary Motions of Animals," fixed the attention of physiologists throughout Europe on its author. His more practical work "On the Sympathy of Nerves and on Nervous, Hypochondriac, or Hysteric Disorders," published in 1764, is a commentary on the former, and a practical illustration of its doctrines. Whence in the present summary both works are considered together, though in the Memoir itself each work is separately treated of.

The first object of the Memoir, under this head, is to show by sufficient proofs that Whytt was not a follower of Stahl,—that he was no more an Animist or Semianimist, than the major part of physiologists at the present moment,—that while Whytt conceived it more conducive to simplicity to represent his sentient principle as a part of the soul, he expressly declares it to be superfluous to dispute with any one who holds doubts thereon, because all his views are independent of that idea, and possess the same truth, whether the sentient principle be or be not accounted a part of the soul. Further, that this sentient principle being destitute of reason, intention and consciousness is really nothing but a physiological force, united with the nervous centre, susceptible of being so far excited by impressions brought by the afferent nervous fibrils, as to communicate motor force to the efferent nervous fibrils which proceed to contractile organs. That such is exactly the light in which Cullen places Whytt's doctrine, referring to Whytt's own expression, that under the appropriate impressions, the power is as certainly determined to bring about these motions, "as is a scale which, by mechanical laws, turns with the greatest weight." That notwithstanding the denial of any consciousness in the case, it is true that the term sentient, and the quality of ungratefulness ascribed to the impressions concerned, create a confusion of ideas; but that that difficulty had

its source in the want of appropriate words (greater in Whytt's time than now) to express the effect of physical agents on organic tissues. That there has always prevailed in physiology a tendency to express in a term not merely the property, but the cause of that property, which is exemplified in the contrast between the nearly synonymous words contractility and irritability,—the former signifying nothing more than the susceptibility of contraction, while the latter, the older word, bears reference to the cause of that susceptibility. That the idea attached by Whytt to "sentient principle," while he denies that it involves consciousness, may be gathered by some consideration of what dwelt in Glisson's mind, when, speaking of the obvious effect of impressions on the spinal cord in animals after decapitation, he says the cord perceives without sensation.

The Memoir referring to the contrast between the effect of a drop of boiling water suddenly falling on the naked foot, and the effect of the sight of a drop of boiling water about to fall on the naked foot, points out that in the latter case the foot is moved by an intelligible force, namely, a volition, but in the former case, by a latent force, which is what Whytt calls his sentient principle. Further, if it be said, why introduce any force, sentient or not sentient, where nothing is by any research discoverable, that Whytt felt himself obliged by the usage of his age to invent an hypothesis, that some force might seem to intervene between the impression on the afferent nerve and the motor power imparted to the efferent nerve; and that if he had felt himself at liberty to omit this hypothesis, his view would have been in general terms exactly that of the present day,—namely, that impressions made on the peripheral extremities of afferent nerves are reflected through the nervous centre into motor influence, transferable by efferent nerves to contractile organs. Again, that the modern view does not reject the idea of a force intervening between the impressions and the reflected motor influence, but merely omits all mention of it, because the connection between the impression and the subsequent motion is not spoken of in relation to cause and effect, but merely as the observed law of an antecedent and consequent, whence that Whytt's mode of thinking does not in general terms differ from the modern view, except that he attempted to solve a difficulty which the modern view declines to meddle with.

The Memoir, however, affords another reason why Whytt felt

obliged to interpose an active cause between the impression on the afferent nerve and the motor influence in the efferent nerve, inasmuch as no consistent attempt had then been made to assign separate offices to particular parts of the nervous centre; and the idea that a part of the tissue of the nerves and brain (such as the white fibres in both), might be merely conducting cords, while another part, such as the grey substance, might be the exclusive origin of force, had not then arisen, whence, as he himself states, that his view was unsatisfactory to explain why an afferent nerve bringing an impression from an external part to one point of the nervous centre, should have its effect reflected into an efferent nerve arising at a distant point of the same centre, unless some influence pervading the whole nervous centre, and therefore the space between the two nerves, were the exciting force, such as his sentient principle.

The Memoir further shows, that though Whytt did not attempt to assign separate offices to separate parts of the nervous centre, understood as including the encephalon and spinal marrow, yet, when explaining the movements in decapitated animals, he suggests the idea that the spinal cord may be capable of independent action, as in tortoises, which live months after being deprived of the brain; while it also affords proof that though Whytt made no pretensions to improve the anatomy of his age as respects the nervous system, he was the authority referred to for seventy years for the hypothesis now recognised as an important fact,—namely, that the ultimate fibrils of the nerves, amidst all their combinations into cords, plexuses, and the like, pass unbranched and isolated from their origin to their termination. Again, it is maintained that this hypothesis could not fail by a single step to suggest the division of the nervous system into conducting cords and centres of force, and therefore to lead to the perception of the probable analogy between the ganglionic system in the invertebral animals and the nervous centre in the vertebrata.

The sum of Whytt's view is next exhibited in the Memoir in contrast with the matured state of the same doctrine in the present day, in as far as regards the non-vital involuntary movements,—viz., the closing of the pupil under a strong light; the shutting of the eyelid when the eye is threatened; the adjustment of the membranes of the internal ear by the muscles of the tympanum to the variations of sound; the act of respiration, and its modifications,

sneezing, cough, hiccup, vomiting, deglutition, the evacuation of the bowels and bladder, and such acts as the sudden withdrawal of the foot when a drop of boiling water falls on it. It is further shown that in such acts generally, there is a consciousness of the impression and a consciousness of the muscular act determined by it, but that there is no consciousness of the exercise of any intervening power, or of the effect of what Whytt terms the sentient principle. It is further stated, that while the discovery of numerous before unnoticed relations between the several parts of the nervous system has largely explained the conformation of the nervous organism, there has not been a corresponding advance in the knowledge of the activities therein operative, so that the same forms of expression are applicable to Whytt's system and to the matured state which his views have now assumed.

The Memoir goes on to state that Unzer was the first who followed Whytt in such a mode of considering nervous action; that while it is acknowledged that Unzer's book is one of great ability, it is a mistake to think that his reflex action of nerves is an advance upon Whytt's,—that it is, on the contrary, retrograde, as the reflex action which he describes is made dependent on communications of nerves in their course analagous to the explanation given by Willis of sympathy. That Prochaska did make a considerable advance; that reflex action in his hands has its seat in the common sensorium or cranio-spinal axis, or excludes the cerebrum and cerebellum, while he describes it as a law written on the medullary pulp of the sensorium,—that is, he ascribes it to no principle or force, though his expression implies the latent existence of such a principle or force. That Marshall Hall is entitled not only to the credit of having given a new impulse to the study of this part of physiology, but of having made the great advance of showing that each segment of the spinal cord and *medulla oblongata* possesses a separate power of imparting reflex action to the nervous fibrils which originate in it, whenever certain impressions are brought to that segment by afferent nerves which terminate there.

In reference to Whytt's views of sympathy which belong to the second of the works mentioned before, his sympathetic actions come under the same head as the non-vital involuntary motions, or depend on impressions reflected into motions through the nervous centre. The sympathetic sensations are either the result of mental

states acting on the nervous centre, and thence on nerves of sense, or sensations produced through one set of nerves reacting on other nerves of the same character. The latter idea is manifestly the same as what in modern times has been termed the radiation of sensation.

With respect to Whytt's controversy with Haller, and the several papers published thereon, it referred to the dependence or non-dependence of irritability, now termed contractility, on nerves,—the former opinion being maintained by Whytt, the latter by Haller. This subject was largely experimented on by Whytt, whose mode of thinking gained many converts in his own time and in subsequent years. It has happened, however, that Haller's views in this particular prevail at the present time, with this understanding,—that though the contractility of the organs concerned in the vegetative functions is not regarded as dependent on nerves, yet the organs of all such functions are believed to be very largely modified by an influence derived from nerves.

As the Memoir itself is of considerable length, and is mainly devoted to the elucidation of the two works above referred to, what has just been said gives but an imperfect idea of the entire character of these principal works of Whytt.

The Memoir concludes with some notice of his other papers, and in particular with a short view of his posthumous work on acute hydrocephalus, on which, in several particulars, he is an original authority.

3. On a difficulty in the Theory of Rain. By James Dalmahoy, Esq.

The difficulty which the paper discusses is the paradoxical fact discovered by Dr Heberden,—namely, that if there be three exactly similar rain-gauges, and one of them be placed on the ground, the second on the roof of a neighbouring house, and the third on a still higher edifice, then, notwithstanding every variety in the positions of these gauges as respects surrounding objects, and notwithstanding the prevalence of the opposite conditions of high wind and of absolute calm, it is observed that the lowest gauge receives more rain than the middle one, and the middle gauge more rain than the upper one.

The paper endeavours to show the inadequacy of the explanations

which have hitherto been given of this difficulty, and quotes, on this point, the authority of Sir John Herschel. It then proceeds to prove, both theoretically and by observation, the existence of a slow downward current of air mingled with minute globules of water, the current itself being the effect of the rain, and originating in the cloud from which the rain proceeds. The twofold agency of this downward current in producing the paradoxical results is then explained; and the paper concludes with a numerical estimate, the object of which is to prove that the quantity of water which it is necessary to assume as being contained in a given volume of the atmosphere, *at a given time*, in order to account for even the more remarkable results on record, is too small to give rise to the appearance of cloud; and so, by proving this, to obviate what would otherwise have been a formidable objection to the proposed explanation of the phenomenon.

4. On the Structure of the Bark of *Araucaria imbricata*, with special reference to Palæontology. By John Hutton Balfour, A.M., M.D., F.R.S., Sec. R.S.E., Professor of Medicine and Botany.

The frost of December 1860 caused serious damage to trees and shrubs in the Botanic Garden of Edinburgh. On the morning of 24th December, Fahrenheit's thermometer stood at 6° below zero, according to the Kew standard. An account of the injury inflicted has been already published in the Transactions of the Botanical Society of Edinburgh. It has been stated that the great cold in the garden, as compared with other places near Edinburgh, may be accounted for by its low sheltered situation, and the descent of the heavy cold atmosphere from the more elevated localities around.

Among the plants which suffered were two very fine specimens of *Araucaria imbricata*, which had stood for upwards of thirty years, and one of which had attained the height of $24\frac{1}{2}$ feet, with a circumference of 4 feet at the base of the stem, and with twenty whorls of branches. These trees, which were great ornaments of the lawn in front of the range of hothouses, have been cut down. An opportunity was thus afforded of examining the structure of their wood and bark. The former is very hard and heavy, and promises to be valuable timber. In regard to the latter, the scars

and markings, and their relation to the leaves, seem to deserve special notice. The sharp-pointed triangular hard and spirally arranged leaves are remarkably persistent. None of the plants in the garden have ever shed their leaves. They become sometimes of a brown colour; but even then they continue to adhere to the stem, and appear as unsightly appendages. In one of the plants cut down the leaves show a splitting at the base, apparently from distension in the parts underneath, similar to what takes place in the petioles of many palms before they are detached. It is possible that, in the Araucaria, the splitting of the basis of the leaves may sometimes be the precursor of their fall. From the lower part of the leaves prolongations extend along the surface of the bark, and give rise to peculiar markings, which are well seen when the leaves are cut off close to their union with the stem (fig. 1). The base of the

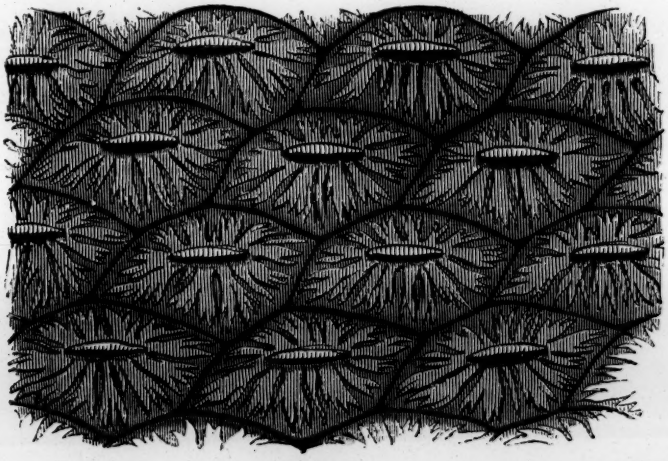


Fig. 1.

leaf remaining in the bark has the form of a narrow elongated ellipse, surrounded by cortical foliar prolongations. The markings on the bark, viewed externally, have a somewhat oblique quadrilateral form. The leaves, when examined by the microscope, show stomata on both surfaces, running in lines, not unlike the appearance presented by stomata in Equiseta.

On removing the epiphlœum or outer bark, and examining its inner surface, we remark a difference in the appearance presented at the lower and upper part of the stem. In the lower portions the markings have an irregular elliptical form, with a deep depres-

sion, and fissures where the leaves are attached (fig. 2). Higher up the epiphlœal markings assume rather more of a quadrilateral

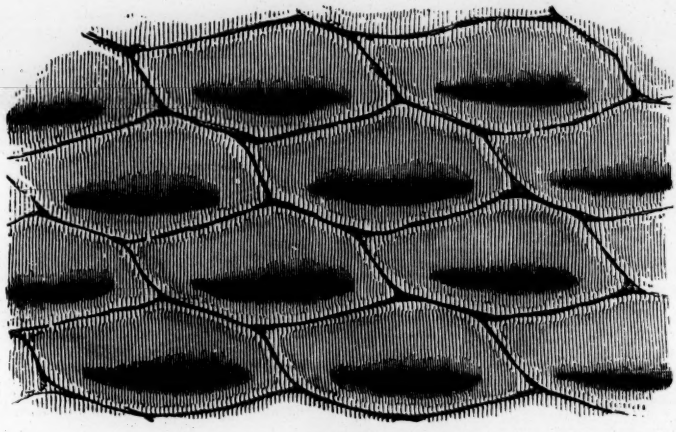


Fig. 2.

form, with the depressions less deep, and the fissures for the leaves giving off prolongations on either side. Farther up the markings are smaller in size, obliquely-quadrilateral, and present circular dots along the boundary lines chiefly (fig. 3). Higher still the

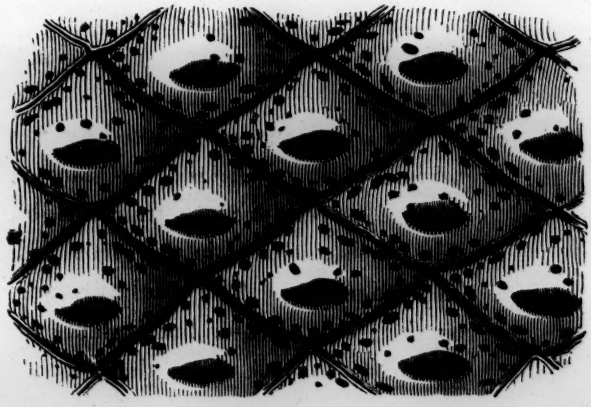


Fig. 3.

quadrilateral form becomes more apparent, and the dots disappear (fig. 4). The epiphlœum thus presents differences in its markings at different heights on the stem.

The middle part of the bark, or mesophlœum, is well developed, and is of a spongy consistence. When examined microscopically it is seen to be composed of cells of various shapes—some elongated

fusiform, others rhomboidal, others with pointed appendages. The variety of forms is very great, and it is possible that this may be partly owing to the effects of frost on the cells. On the spontaneous

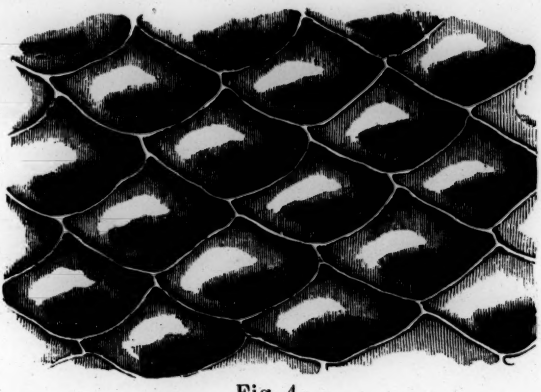


Fig. 4.

separation of the bark, the mesophlœum was seen to consist of distinct plates of a more or less quadrilateral form, with some of the edges concave and others convex, a part in the centre indicating the connection with the leaf, along with which it is detached. In Fig. 5 a leaf is shown with a mesophlœal plate attached.

Fig. 5.

The endophlœum, liber or inner bark, is of a fibrous nature, and consists of elongated woody tubes.

The appearances presented by the outer and middle bark of *Araucaria imbricata* bear a marked resemblance to those exhibited by certain fossils included in the genera Sigillaria and Lepidodendron. The sculpturesque markings on the stems of these fossil plants have induced geologists to look upon them as allied to the ferns and lycopods of the present epoch. But it is evident, from the specimens of Araucaria now laid before the Society, that much caution is required in making this determination. Other points of structure must be examined before a proper decision can be formed; when, for instance, the presence of scalariform tissue, or of punctated woody tissue has been satisfactorily shown under the microscope, we are entitled to

hazard an opinion as to the affinities of the fossils. In many instances, however, external appearances are the only data on which to rely for the determination of fossil genera and species; and rash conclusions have often been drawn by geologists who have not been conversant with the structure of plants.

The Araucaria markings point out the need of care in drawing conclusions, and their variation at different parts of the bark indicate the danger of a rash decision as to species. There can be no doubt that in vegetable palæontology the number of species has been needlessly multiplied—any slight variation in form having been reckoned sufficient for specific distinction. We can conceive that the Araucaria bark markings in a fossil state might easily supply several species of Sigillaria, or of Lepidodendron. The geologist, with little knowledge of the present flora of the globe, ventures often to decide on an isolated fragment, which a well-informed botanist would hesitate to characterise. Hence the crude descriptions of fossil vegetable forms, and the confusion in which Palæophytology is involved. Every geologist who examines fossil plants ought to be well acquainted with the minute structure of living plants, the forms of their roots, stems, leaves, fronds, and fructifications; the markings on the outer and inner surfaces of their barks, on their stems, and on their rhizomes; the localities in which they grow, and the climates which genera and species affect in various parts of the world.

The following Gentlemen were elected Ordinary Fellows:—

Edward Francis Maitland, Esq., Advocate, Solicitor-General for Scotland.

Rev. Robert Boog Watson, late Chaplain to the Forces.

The following Donations to the Library were announced:—

Proceedings of the Royal Society of London. Vol. XI. No. 48. 8vo.—*From the Society.*

The Journal of the Chemical Society. Vol. XV. Part 3. 8vo.—*From the Society.*

Proceedings of the Royal Horticultural Society. Vol. II. No. 4. 8vo.—*From the Society.*

The Assurance Magazine and Journal of the Institute of Actuaries. No. XLVII. 8vo.—*From the Institute.*

Almanaque Náutico para el año 1863. Calculado de órden de S. M. en el Observatorio de Marina de la Ciudad de S. Fernando. Cadiz, 1861. 8vo.—*From the Director of the Observatory.*

Pocket Diagram of Mean Pressures of Expanding Steam. By W. J. Macquorn Rankin, C.E., LL.D.—*From the Author.*

London University Calendar for 1862. 12mo.—*From the University.*

Monday, 21*st April* 1862.

PROFESSOR CHRISTISON, V.P., in the Chair.

The following Communications were read:—

1. On the Theory of Numbers. By H. Fox Talbot, Esq.

2. On the Carboniferous Volcanic Rocks of the Basin of the Forth. By Archibald Geikie, Esq., F.R.S.

After referring to a previous communication to the Society, in which the author had given an outline of the chronology of the igneous rocks of Scotland, he proceeded in the present paper to describe in detail the character of the volcanic phenomena in one district—that of the carboniferous system of the Forth basin. The igneous rocks of this district consist partly of doleritic and felspathic lava-form masses, and partly of various kinds of ash or trap-tuff. These materials present a considerable diversity in their modes of arrangement. But the author had found that all the volcanic hills of the district might be reduced to three types of structure:—1. A simple cone of ash, round and over which the ordinary sedimentary accumulation of the carboniferous period had been deposited. 2. A cone of ash with the crater filled up by a neck or plug of basalt. 3. Sheets of different lavas with intercalated ash or sedimentary matter.

He described in detail the succession of volcanic phenomena in the Lothians and in Fife, pointing out how local and limited the eruptions had been as a whole. They were confined to the earlier half of the carboniferous period, no interbedded igneous rock having yet been found in the formations that overlie the carboniferous limestone. The whole of this district appears to have been dotted

over with volcanic cones, from each of which independent eruptions took place. To such a kind of scenery the nearest parallel in Europe is probably the region of Auvergne and the Haute Loire, which the author had recently visited for the purpose of comparison. The concluding part of the paper was devoted to a sketch of the subterranean movements of upheaval and depression which can be shown to have taken place during the volcanic period in the basin of the Forth, and to some remarks on the abundance of life in the immediate vicinity of the volcanic orifices.

3. On the Constitution of Society in this Country, with reference to the Proportion which Male Life bears relatively to Female Life, and the Effects of an Excess of Female Life. By W. T. Thomson, Esq.

The object of this paper is to show the prejudicial effect which the excess of females has upon the condition and moral well-being of society in this country.

Excess of Males at Birth.

"According to the Twenty-Second Annual Report of the Registrar-General of *England* for 1859 (published in 1861), 689,881 births were registered in that year, viz.—

Male Children, . . .	352,662
Female Children, . . .	337,219
Total, . . .	689,881

that is, 104·58 males to 100 females.

Of these there were born—

In wedlock, . .	329,668 males,	315,462 females.
Out of wedlock, .	22,994 „	21,757 „
	352,662	337,219

showing 105·7 males born in wedlock, to every 100 females so born, and 104·5 males born out of wedlock to every 100 females so born."

"According to the Second Annual Report of the Registrar-General for Scotland for 1856 (published in 1861), 101,821 births were registered in that year—

Male Children, . . .	52,239
Female Children, . . .	49,582
	101,821

that is, 105.3 males to 100 females.

Of these there were born—

In wedlock, . .	47,761	males,	45,365	females.
Out of wedlock, .	4,478	,,	4,217	,,
	52,239		49,582	

showing 105·28 males born in wedlock to every 100 females so born, and 106·19 males born out of wedlock to every 100 females so born."

"The proportion between male and female births is found by observation not to differ at any time materially from the results here quoted for a single year, although the variation in different localities is peculiar; and there is, it will be perceived, an unexplainable difference in the relative proportions among legitimate and illegitimate children."

Excess of Females in Life.

"It would naturally be inferred from these facts, so many more males being born than females, that male life preponderated both in England and Scotland; but the state of the entire population, as shown by the census of 1851, will exhibit conclusively that, whatever may have been the relative proportions at birth, the actual condition of the country, comparing males with females, is very different in its results."

Population of England and Wales at the Census in 1851.

	1851.	
	Males.	Females.
England and Wales, . . .	8,781,225	9,146,384
Scotland, ...	1,375,479	1,513,263
Islands in the British Seas, . .	66,511	76,405
	10,223,215	10,736,052

"Here the great fact is exhibited that there were about 4·2 per cent. more females than males in England, 10 per cent. more females than males in Scotland, and nearly 15 per cent. more females than males in the Islands in the British Seas in 1851; while, in 1861, the per-centage had increased to 5·57 more females than males in England, 11·56 per cent. more females than males in Scotland.

"With these facts before us, it requires no lengthened proof to satisfy the most casual observer that the great design of Providence in providing a larger number of males than females has been frustrated."

"This abnormal state of society has arisen chiefly from two causes:—

The greater mortality of male life as compared with female life, more particularly in early years, and

The emigration of a larger number of males than females."

"I shall now endeavour to prove that these causes of disorganisation exist."

The greater Mortality of Male Life.

[Mr Thomson here exhibited a table showing the population, deaths, and mortality generally in England and Wales from 1838 to 1844, a period during which the mortality was not disturbed by epidemics.]

"It will be perceived," he proceeded, "that from birth to five years of age, male children died during the seven years at the rate of 7·072 per cent., and female children at the rate of 6·037 per cent., the actual numbers dying having been 517,897 males and 446,910 females. From five to ten years the difference was not so great between the sexes, 61,659 males to 59,903 females. From ten to thirty-five (the principal period of child-bearing) the female mortality was somewhat greater. The male mortality then increased, and continued greater till the close of life."

"The feature which first attracts attention in considering these results is the great mortality in the early years of male life. 70,000 male children were lost during the first five years of life, that being the excess of male deaths as compared with the deaths among females. Similar results will be found to obtain year by year in other years, according to the reports of the registrar, and such a loss cannot fail to have a most prejudicial effect on the condition of society; it not only drains away the natural excess of males provided by God's providence, but, by the greater mortality of males, an excess of female life is left prejudicial to the wellbeing of females themselves, and of males also. It is impossible that this infringement of the laws of nature can lead to any but one result—it has led to immorality and suffering, and will continue to do so; for it is not for one moment to be supposed that it was the intention of the Deity to create male children in excess to be swept away within a few years after entering life. But, indeed, the excess of male deaths is not the sole measure of evil, for no doubt female mortality is also greater than it should be; and, in like manner, the male deaths, were they

only equal to the female deaths, would also be greatly in excess of what they should be. It is a sad state of matters—a national calamity, and demands attention."

"Again, above thirty-five years of age to the end of life, the male deaths bear an unfavourable comparison with the females. Men sink exhausted, worn out, leaving widows and young children to increase our difficulties. The loss of infant life is a great evil, but the loss of man in the prime of life is a greater. No one can fill the father's place in a poor man's home; his death is frequently an immediate fall from competence to destitution. The struggle is for existence, and children are brought up, if reared at all, weak in body and mind, oftener indeed cut off by disease, helping to fill up in rotation the death-roll of our Juggernaut, which year by year demands its sacrifice. If they survive, the want of means denies them education, and they are often left a legacy to fill our jails and poor-houses. A few years added in the aggregate to male lives would create a great change in all this; widows would be reduced in number, and many children now thrown helpless on the world would be supported and educated in their earlier years. Our unnatural position acts and reacts to our disadvantage, and the excess of male deaths at the periods shown is an ever fruitful source of sin and misery."

"If this is bad in England, it is worse in Scotland. That country has many other difficulties also to contend with peculiar to its position; but as I afterwards propose to limit my observations to that country, I shall reserve further remark."

In order to prove that the increased death rate among males was not increased by special or local causes, Mr Thomson introduced a table showing that the results over the whole of England are much the same, exhibiting a greater mortality almost universally among the male sex.

Also a table taken from the returns of the Registrar-General, exhibiting the per-centage of deaths among males and females during twenty years, with the relative proportions which these deaths bear to each other, proving at the same time that the greater mortality among male lives is constant.

These tables proved conclusively the first proposition, that the mortality of male life is greater in England than that of female life. Mr Thomson then proceeded to show what causes have produced these results:—

Deaths of Males and Females in England during the year 1858.—*From the Registrar-General's Twenty-first Report.*

	Males.	Females.	Excess Males.	Excess Females.
I. ZYMOTIC DISEASES.				
Miasmatic.—Small-pox, Measles, Scarlatina, Fevers, &c.,	52,325	53,953	...	1,628
Enthetic.—Syphilis, Stricture of Urethra, &c.,	698	497	201	...
Dietic.—Privation, Want of Breast Milk, Alcoholism, &c.,	1,304	808	496	...
Parasitic.—Thrush, Worms, &c.,	745	641	104	...
	55,072	55,899	861	1,628
II. CONSTITUTIONAL DISEASES.				
Diathetic.—Gout, Dropsy, Cancer, Noma, Mortification,	6,440	10,350	...	3,910
Tubercular.—Scrofula, Tabes Mesenterica, Phthisis, &c.,	32,035	33,591	...	1,556
	38,475	43,941	...	5,466
III. LOCAL DISEASES.				
Diseases of Nervous System.—Cephalitis, Apoplexy, &c.,	28,841	25,120	3,721	...
Organs of Circulation.—Pericorditis, Heart Disease, &c.,	8,086	8,340	...	254
Respiratory Organs.—Laryngitis, Bronchitis, Pleurisy, &c.,	34,672	30,844	3,828	...
Digestive Organs.—Gastritis, Enteritis, Peritonitis, &c.,	9,449	9,797	...	348
Urinary Organs.—Nephritis, Ischuria, Kidney Disease, &c.,	3,332	1,351	1,981	...
Organs of Generation.—Ovarian and Uterine Disease, &c.,	53	1,095	...	1,042
Organs of Locomotion.—Arthritis, Joint Disease, &c.,	675	489	186	...
Integumentary System.—Phlegmon, Ulcer, Skin Disease, &c.,	697	648	49	...
	85,805	77,684	9,765	1,644
IV. DEVELOPMENTAL DISEASES.				
Congenital Malformations and Developmental Diseases of Children,	6,884	5,528	1,356	...
Developmental Diseases—Adults.—Childbirth, &c.,	...	2,114	...	2,114
Developmental Diseases—Old People—Old Age,	11,954	16,555	...	4,601
Diseases of Nutrition.—Atrophy and Debility,	13,954	12,906	1,048	...
	32,792	37,103	2,404	6,715
V. VIOLENT DEATHS.				
Accident or Negligence,	9,182	3,341	5,841	...
Homicide, Murder, and Manslaughter,	215	129	86	...
Suicide.—Gunshot Wounds, Cut, Stab, Poison, Drowning, &c.,	921	354	567	...
Execution.—Hanging,	9	...	9	...
	10,327	3,824	2,824	...
VI. SUDDEN DEATHS.—*Causes not ascertained,*	1,826	1,270	556	...
VII. CAUSES NOT SPECIFIED OR ILL-DEFINED,	2,923	2,715	208	...
	227,220	222,436	20,237	15,453

"The diseases of which men die in greater proportion than women, thus appear to be those which arise from exposure, bad habits, overwork of mind and body, accidents, violent deaths; while the male infant seems to have an unaccountable tendency to fatal diseases, which are less destructive in the female child."

(The author here introduced a table, showing the causes of death in Scotland at different periods of life, under ten years, from all diseases, in 1856.

This table showed an excess of male deaths at every period of age, and by every one of the diseases specified, viz:—

Zymotic Class,
Diseases of Uncertain Seat,
Tubercular Class,
Brain—Nervous System,
Organs of Circulation,
Respiratory Organs,
Organs of Digestion,
Urinary Organs,
Organs of Generation,
Organs of Locomotion,
Skin, &c.
Malformation,
Premature Debility,
Atrophy,
Age,
Sudden Deaths, and
Violent Deaths.

the total result being 14,053 male deaths to 12,314 female deaths under ten years of age.)

"The principal diseases which occasion death in children," Mr Thomson continued, "are zymotic diseases, diseases of respiration and digestion, tubercular diseases, and general debility; but there seems to be nothing yet known connected with the principal causes of death that can account for a greater mortality among male children than among female.

"On this part of the subject I shall not dwell, the facts are sufficient for my purpose in this paper. I have given one table of diseases from English observation, and the other from Scotch observation, to show the identity of result in both countries."

The Emigration of a larger Number of Males than Females, and Excess of Male Life in the Colonies.

"There is no want of proof under this head, but I must endeavour to make that proof so conclusive, that there can be no question on the point. I shall therefore take my figures entirely from Government sources, and leave them to speak for themselves."

(Here Mr Thomson exhibited a table which proved distinctly the

immense loss to this country of male life which has taken place in consequence of emigration—the total loss having been 272,416 males during the ten years 1848 to 1857 in excess of females, and upwards of 40,000 in 1858, 1859, and 1860—men generally, if not invariably, in the prime of life, full of health and strength.

The total of emigration from the United Kingdom during these ten years was stated to be 1,443,382 males and 1,183,430 females, besides 125,956 whose sex was not distinguished. Also, that in 1858, 1859, and 1860, the male emigration amounted to 202,347 persons, and the female emigration to 159,424 persons.

Mr Thomson illustrated this point still further by reference to the population of different colonies.)

Return showing the Population of New South Wales, 1821 *to* 1857 :—

Year.	Males.	Females.	Gross Population.
1821 . . .	21,693	8,090	29,783
1828 . . .	27,611	8,987	36,598
1833 . . .	44,688	16,173	60,861
1836 . . .	55,539	21,557	77,096
1841 . . .	87,298	43,558	130,856
1846 . . .	114,769	74,840	189,609
1851* . . .	106,229	81,014	187,243
1856 . . .	147,091	119,098	266,189
1857 . . .	171,673	133,814	...

"In 1851 there was a deficiency of 252 females to every 1000 males. Proportion, 56·8 males to 43·2 females."

"In 1856 there was a deficiency of 208 females to 1000 males. Proportion, 55·2 males to 44·8 females."

Total Population of New South Wales—1856.

	Under 14.	14 to 60.	60 and Upwards.
Males . .	50,276	91,739	5076
Females . .	49,982	67,104	2012
Excess of Males	294	24,635	3064

* Separation of Port-Philip in this year causes decrease.

Victoria.

	Males.	Females.
1854 . . .	155,876	80,900
1857 . . .	264,334	146,432
1857 (ages 20 to 40)	84,790	34,843
1858 (office returns) .	308,983	176,786
1860 . . .	341,628	203,049

"Tasmania, again, according to the population returns of 1857, shows the following results:—

Males . .	45,916
Females . .	34,886
Excess of Males .	11,030, or 24 per cent.

Ages 21 to 45, males 20,913, females 13,610.

New Zealand, 1857 . Males 29,435 Females 22,720.
Western Australia, 1857 Males 9028 Females 4573."

(The following extract was given from the Twentieth General Report of the Emigration Commissioners, 1860, regarding the disparity of sexes in Victoria, showing distinctly that the evil produced at home by emigration was productive of serious evil in the colony:—)

"The census of 1857 discloses some remarkable facts respecting the disparity of sexes in Victoria, which is thus noticed by Sir Henry Barkly in his despatch transmitting a portion of the tables.

"It now appears that, though considerable improvement in this respect took place between 1854 and 1857, yet that the effective disproportion at the latter period was far more serious than would be deducible from the fact of there being 163 males to every 100 females in the entire population. Since tabling the portion of it above the age of twenty years there were no less than 217 males to that number—the proportions below that age being pretty nearly equal.

"The effect of this disparity may be more clearly deduced from the tables relating to the conjugal condition of the people, which show that there were 88·355 unmarried men of twenty years of age and upwards to but 12·545 unmarried women of corresponding

ages; or, to raise the age of marriage for men to twenty-one, and lower it to fifteen for women, there was still an excess of 61,859 bachelors, not to add 5112 widowers.

"Even this comparison, however, fails to convey a full sense of the evil as it affects the gold fields, where it appears that the percentage of unmarried men is to that to be found in the seaport towns as 61 to 39; or, to state the case in another form—where the bachelors are to the spinsters in the proportion of more than 20 to 1. There are, moreover, 8096 married men, chiefly in the mining districts, whose wives are not in the colony."

"It is no doubt true that this excess of male life is all above a certain age, according to the age of the colony, the deficiency of females having arisen from the greater emigration of males originally; and it is to be admitted, that as the native growth of population increases, a normal state of life with reference to the proportion of males and females will arise; but in the meantime it occasions great social evils, which afflict most severely the mother country."

General Results.

(Mr Thomson here exhibited an elaborate table showing the relative proportions of males and females of twenty years of age and upwards in England and Wales taken from the census of 1851; also the proportion of births, marriages, and deaths to 100 persons living, likewise children born out of wedlock to 100 births throughout each county.)

"There are curious variations in the results shown in different counties and districts, and east, west, north, and south, yield very different proportions; but the grand total for England and Wales may be read thus:—

For every 100 males there were 108·11 females in England and Wales at the census of 1851.
For every 100 bachelors 101·13 spinsters.
For every 100 husbands 101·31 wives.
For every 100 widowers 198·18 widows.
For every 100 persons living there were (1850 to 1857) 3·399 births.
For every 100 inhabitants there were (1857) ·824 marriages.
For every 100 persons living there were (1857) 2·175 deaths.
And out of every 100 births there were (1857) 6·5 children born out of wedlock.

"It will be found, when we afterwards come to consider the results in Scotland, that female life is very greatly in excess of male life proportionally as compared with England; that the unmarried females and widows are in much larger proportion; and that illegitimacy prevails to a wider extent—the result of the comparison being that there is more illegitimacy where there is a greater excess of female life; but, although I draw this general conclusion, I cannot, in considering the table referred to above, or the table applicable to Scotland which follows, prove in detail that in every county where there is an excess of females there is an excess of bastardy. I must ask my readers to take the wider view of our condition, and deal, as a whole, with the comparative effects, for there are many acting and reacting influences in operation in particular localities which produce results very different from those we anticipated. We must mass the results, and the comparison of Scotland and England is on a sufficiently large scale to give us confidence in our conclusions.

"As an example of the difficulty of drawing conclusions from limited or local facts, let us consider London. We find there 120·53 females for 100 males, 125 spinsters to 100 bachelors, and 296·86 widows for 100 widowers, with only 4·2 children born out of wedlock to 100 births. The hasty conclusion would be, that London is more moral than the whole of England, for we find, in running our eye down the bastardy column, that the return of illegitimate children is less than for any county in England, and more than 2 per cent. less than the average for the whole kingdom. I am afraid that that conclusion will not stand investigation. I do not mean to say that the solution of the problem is an easy one, but I do not think the deduction, based on a purer morality, is correct. It is more than probable that the great prevalence of prostitution has the effect of diminishing child-bearing among unmarried persons; and I have no doubt that every large town will show the same result."

"I have now shown—

"1. That the male births exceed the females in a certain proportion, which, in the state of this country, may be called a constant ratio, or, in modern scientific language, 'an ultimate statistical unit,' if there be such a thing.

"2. That males die more rapidly than females, more particularly in early life.

"3. That males emigrate in larger numbers than females.

"4. That the amount of female life in this country exceeds the amount of male life."

Scotland.

"I will now confine my remarks to Scotland, as it is to the state of that country I wish more particularly to direct your attention, and the contrast afforded by the following figures will serve as a very proper introduction to my remarks:—

		In England and Wales.	In Scotland.
Total Females to 100 males,	Census 1851,	108·11	121·00
,, Spinsters to 100 bachelors,	do.	101·13	123·63
,, Wives to 100 husbands,	do.	101·31	102·26
,, Widows to 100 widowers,	do.	198·18	271·13
,, Births to 100 persons living,	Years stated,	3·399	3·417
,, Marriages to 100 inhabitants,	do.	·824	·676
,, Deaths to 100 persons living,	do.	2·175	1·977
,, Children born out of wedlock to 100 births,	do.	·650	·900

"We are altogether in an abnormal state. Our young men have left us; our maidens are unmarried; our widows are in excess; our wives are deserted; our marriages are deficient; illegitimacy is rampant; and from all this flow many crimes.

"After carefully considering these sad figures, and having given much attention to the Report of the Registrar-General of Scotland, my strong conviction is, that the excess of female life is mainly at the root of that great evil—illegitimacy. I have no doubt that local customs and habits increase it, and that race has something more or less to do with its extent in particular counties; but the root of all is our abnormal position, already explained. It is not very easy to separate the races which have peopled Scotland; but to those who know the appearance of the inhabitants, their customs and manners, in different parts of Scotland, it will, I think, appear a task which at least, probably, may be performed. But without attempting any minute classification, and merely keeping in view what is already known as to the settlement of the different races of inhabitants, I would simply refer to the Registrar-General's division, according to

which my results are tabulated. A glance at the table will satisfy the most casual observer, that the north and west give very different results from the southern and eastern portions of the kingdom; and if the north-west and north-east alone be compared, portions of the kingdom where there has, comparatively, been little intermixture of two well-marked distinct races, the following is the result:—

	Children Born out of Wedlock to 100 Births.
North-Western, . . .	5·8
North-Eastern, . . .	15·

"I request particular attention to the following table, which has been prepared on the same plan as the table for England above referred to:—

Abstract of Table, showing the relative Proportion of Males and Females of Twenty Years of Age and Upwards in Scotland, taken from the Census of 1851; *also Proportion of Births, Marriages, and Deaths to* 100 *Persons living.**

Scotland.	Proportion of Females to Males. Census 1851.				Proportion of Births, Marriages, and Deaths.			
	Total Females to 100 Males.	Spinsters to 100 Bachelors.	Wives to 100 Husbands.	Widows to 100 Widowers.	Births to 100 Persons living, 1859.	Marriages to 100 Inhabitants, 1859.	Deaths to 100 Persons living, 1859.	Children born out of Wedlock to 100 Births, 1859.
Scotland . . .	121·00	123·63	102·27	271·13	3·417	·676	1·977	9·
Northern Counties .	...	...	...	...	2·521	·489	1·327	5·4
North-Western Counties	...	...	...	...	2·532	·475	1·406	5·8
North-Eastern „	...	...	...	...	3·209	·618	1·661	15·
East Midland „	...	...	...	...	3·086	·597	1·874	9·8
West Midland „	...	...	...	...	3·107	·589	1·832	7·2
South-Western „	...	...	...	...	4·249	·833	2·516	7·2
South-Eastern „	...	...	...	...	3·323	·745	1·867	8·5
Southern „	...	...	...	...	2·911	·572	1·740	13·3

Conclusion.

"Holding, then, illegitimacy to be a blot on our national character, which has been proved, and is admitted, and assuming that it is produced and increased by our abnormal condition and the other causes

* The table given by Mr Thomson exhibited the results for each county.

above stated, let us at once proceed to consider what are the means which may be adopted to cure the evil and its consequences, which are so many and so grievous. I would consider the question from two points of view :—

" 1. With reference to the existing excess of female life.

" 2. With reference to the loss of male life.

" We have also to keep in view the question of local customs, and the habits of the people generally, as bearing on morals. The question of race, I am afraid, I must leave for further inquiry and discussion ; but I anticipate we must give the moral crown to the Celt—our Celtic race showing certainly, if we may judge from figures, a higher code of morals than the Northman and Saxon.

" The first and most obvious call, not upon Scotland, but upon the Government of the country, is to promote respectable FEMALE EMIGRATION. I am aware that endeavours have been made to do this, not only by the Emigration Commissioners, but by the colonies themselves, but it has never been attended to on a sufficiently extended scale. Both at home and abroad, comfortable ' homes,' with adequate superintendence, should be provided by the Government, and that superintendence should be by means of local committees partly composed of ladies, in correspondence with similar committees throughout the whole country. Proper matrons should accompany each ship, and pains should be taken to preserve the highest moral tone, from the time of leaving home till the final destination of the emigrants is reached. I am aware that great difficulties have arisen in carrying out such arrangements already, when tried ; but I am convinced, that under a proper system, and with the assistance of the colonies themselves, the scheme could be more effectually carried out. All ladies should take an interest in such a scheme for the sake of their sex ; and the money of the nation and its colonies should be freely expended to bring about a result, beneficial alike to the mother country and to the colonies themselves.

" In illustration of the urgent demand for females in Otago, New Zealand, I beg attention to the following memorandum, which I have received from the agent in Edinburgh for emigration to that colony, while writing this paper :—

" I think you expressed a wish, when I saw you the other day in your office, to have a statement of the population of Otago. I

have looked into the matter, and the following results may be taken as correct:—

POPULATION IN 1855.

Males—European origin, . .	1562
Females— do. do., . . .	1290
Excess of males, .	272

"(The Maories or natives, present number about 56,000, are nearly all located in the North Island of New Zealand. The number in Otago stated in next table. They are rapidly dying out.)

Population of Otago, by a Census taken 31*st December* 1859.

	Males.	Females.	Total.
Europeans, ...	5150	3749	8899
Maories, or natives, . . .	238	195	433
	5388	3944	9332
Females as above, . . .	3944		
Excess of males, . . .	1444		

"The population had increased in July 1861 to about 15,000, from excess of births over deaths, but chiefly from emigration from Great Britain. I have no tables to give showing the numbers of males and females comprising this number 15,000; but I know that from the greater number of males who have passed through this office, the table, if I could give it, would show that the evil had gone on increasing in an alarming ratio.

"In July 1861 gold was discovered in Otago, which immediately caused a rush to the province from the neighbouring settlements. The gold discoveries have not as yet much affected the emigration from Britain, but I perceive signs which make me believe that a large number will leave in the spring and summer months. *Three-fourths* at least of those who leave will be males.

"From the *Otago Witness* of 23d November 1861, I extract the following table, which shows the rate at which the population of Otago is increasing:—

Passenger Arrivals at the Port of Dunedin, Otago, from 1*st July to* 30*th October* 1861.

Whence.	Males.	Females.	Children.	Total.
Hobart Town, . . .	563	22	13	
Glasgow, ...	505	202	188	
London, ...	16	7	2	
Sydney, ...	684	11	13	
Geelong, ...	126	2	4	
Launceston, ...	390	8	6	
Newcastle (Australia), . .	131	1	0	
Melbourne, ...	10,765	152	85	
From parts in New Zealand, .	2,161	84	38	
Adult males, ...	15,341	489	349	16,179
Do. females, . . .	489	Of the children, there would be about as many girls as boys.		
Excess of males, . . .	14,852			

"From the foregoing tables you will observe, that before the gold discoveries the males vastly out-numbered the females; while for the last three months of which I have any account, the emigration amounted to 15,341 males, and 489 females.

"I would weaken my case were I to add one word to this description.

"The industrial employment of women engages the attention of many as a remedy for existing evils.

"As I do not think there is an adequate idea abroad as to the extent to which women are already employed in this country, I think it well to give the following particulars as to the occupation or position of females, taken from the census of 1851:—

CENSUS, 1851.

Occupations of Females—Scotland.

CLASS 1.	Persons engaged in the general or local government of the country, . .	359
„ 2.	Persons in the learned professions (with their immediate subordinates), either filling public offices or in private practice, ...	80
„ 3.	Persons engaged in literature, the fine arts, or the sciences, . . .	4,441

Class 4.	Persons engaged in the domestic offices or duties of wives, mothers, mistresses of families, children, relatives, . .	964,533
„ 5.	Persons engaged in entertaining, clothing, and performing personal offices for man,	205,588
„ 6.	Persons who buy or sell, keep, let, or lend money, houses, or goods of various kinds,	8,007
„ 7.	Persons engaged in the conveyance of men, animals, goods, and messages, .	1,353
„ 8.	Persons possessing or working the land, and engaged in growing grain, fruits, grasses, animals, and other products, .	126,041
„ 9.	Persons engaged about animals, . .	680
„ 10.	Persons engaged in art and mechanic productions in which matters of various kinds are employed in combination, .	1,620
„ 11.	Persons working and dealing in animal matters, ...	17,558
„ 12.	Persons working and dealing in matters derived from the vegetable kingdom, .	132,073
„ 13.	Persons working and dealing in minerals,	1,696
„ 14.	Labourers and others—branch of labour undefined, ...	1,901
„ 15.	Independent persons and annuitants, .	16,698
„ 16.	Dependent persons, ...	16,885
„ 17.	Persons of no stated occupation or condition, ...	13,750

Note.—There were, in 1851, 659,084 females alive in Scotland below 20 years of age, and 854,179 above 20. Of these, 136,163 below 20, and 365,234 above 20, were engaged industrially; 964,533 were wives, mothers, children, and others domestically engaged; and 47,333 were annuitants, dependent persons, and persons of no stated occupation.

"It will be perceived that a very large number of females endeavour to support themselves; and I think it probable they have found the kinds of occupation most congenial to them. I am no believer in the industrial employment of women, by forcing them into employments where the labour is fully supplied by men. The point cannot be forced. Some instances may be found where men are in their wrong position, when women should be employed; but it is a complete fallacy to suppose that you can place women, industrially, wherever you think right, without the will of the public and the concurrence of the masters. These things regulate themselves;

and, with the pressure of female labour in the market, women would have forced men out of occupation fitted for them long ago, if they were better suited for such particular occupations than men. Many weak arguments have been used in this good cause, but the whole question is more a fundamental one than is generally imagined. We must restore the balance of female life, and put woman, as far as possible, in her true place—as the helpmate of man, not as a competitor for toil and labour.

"Marriage is woman's true mission, and it should be part of our great scheme of reformation to keep her in that position as much as possible.

"But how stands Scotland in respect to 'marriage?' Lamentable is her case, indeed, as compared with England. The tables I have given for England and Scotland illustrate this fully; and by reference to them you will find, that while in England the marriages in 1857 were as ·824 to 100 inhabitants, the proportion in Scotland in 1859 was only ·676 to the same number. Again, the marriages in Scotland were later in life, and therefore less favourable to that moral condition which early marriage creates, fosters, and perpetuates. The following are the figures:—

Average Ages of Persons Marrying out of every 100 *Married.*

	England. 1859.	Scotland. 1856.
Males under 20 years of age, .	2·637	3·086
,, under 25 ,, .	49·544	40·790
,, under 30 ,, .	75·254	70·166
,, above 30 ,, .	24·746	30·834
Females under 20 years of age, .	13·224	12·565
,, under 25 ,, .	62·631	58·416
,, under 30 ,, .	82·430	82·708
,, above 30 ,, .	17·570	17·292

"These results are for single years; but, one year with another, the results will be found much the same.

"No doubt, where two countries approximate, or rather join each other, speaking the same language, and living under the same

laws, the richer country will attract the male population to engage in trade, &c.; and this element must be kept in view in comparing Scotland and England; but it does not affect the question I am now putting, except in so far as Scotchmen wandering to England may prefer an English to a Scotch wife. But I would deduce from these figures, and from observations made otherwise, the benefits of early marriages.

"But these remedies are all systematic, requiring time to develop them; meanwhile, the evil which we find prevails amongst us should be promptly met by remedial measures. It is a difficult matter to suggest remedies for immediate relief, seeing how fundamentally our system is deranged; but, at the risk of being charged with over-zeal, I shall venture to make a few suggestions.

"1*st*, then, An illegitimate child should be under the supervision of the parochial authorities, whether the parents can support it or not, and each county should be assessed for these children as far as not supported by the parents by a separate assessment. By advocating that illegitimate children should be under the immediate supervision of the parochial authorities, I do not mean that they should be supported by the parish when the parents can do so, but I mean that the fate of each child born out of wedlock in the parish should be carefully watched, even although it entailed more expense and responsibility than at present. It may be argued, that by placing more responsibility on the parochial authorities than at present we would increase the evil; but even if such were at first the tendency, I am firmly convinced that child-murder* would be less common when the parochial authorities had cognizance of such children, while the burden thrown on the landlords would rouse them not only to attend more to the position of the labouring class around them, but would be an inducement to them to urge the clergy to be fully alive to the spread of laxity of morals throughout their parishes, thereby ultimately securing a better state of things.

"2*d*, Our clergy ought to be much in the houses of their parishioners; not as mere formal visitors, but as the best and nearest

* By a return made to the House of Commons in 1861, it appeared that from 31st December 1855 to 31st December 1860, the number of coroners' inquests held upon the bodies of infants within the Metropolitan District (London) alone were 3901,—namely, on males, 2082; females, 1816; sex unknown, 3.

friends of the family—the physicians of their souls. Unless the minister is the kind and affectionate father of his parishioners, following his avocation day by day, making his religion a daily work, one great source of aid in putting down such evils as are prevalent in Scotland must be awanting.

"3*d*, To the landed proprietor—to the manufacturer—to all masters and mistresses, we must appeal for aid.

"To the landed proprietor we would say, instead of bothies for males and females, let all single men and women be boarded, if possible, with the married couples, giving sufficient room to keep all pure; or let there be separate houses for men and women, where they may mess and live together under some superintendence.

"We might also, under this head, appeal to the heavy charge for poor-rate as an argument for exertion on the part of all who are taxed.

"I have before me a set of tables, issued by the Poor-Law Board, giving an account of the number of paupers in 646 unions and parishes at the end of the first half year of 1860.

"There were 162,337 men, 357,271 women, 289,587 children under 16, and 1737 vagrants; the men thus forming 20 per cent., the women 44·1, the children 35·7. Of these 338,497 are described as able-bodied (including the children of the able-bodied); and concerning 303,797 of these, information is supplied by 629 unions of the causes which brought them on the poor-rates.

Causes which brought 303,797 *Persons on the Poor-Rate, Scotland.*

		Men.	Women.	Children.
1. Widowhood—Widows,		...	49,232	...
Children dependent on them,		...	...	123,646
2. Families dependent on Males in Classes 3, 4, and 5—Wives,		...	19,648	...
Children,		...	...	51,294
3. Sickness, accident, or infirmity—				
Their own,	16,116	...	...	...
That of any of the family or a funeral,	7,376	...	...	...
	23,492	...	...	...
4. Husbands non-resident,		...	3,867	10,102
5. Husbands in jail, &c.,		...	1,568	4,470
6. Bastardy—Mothers,		...	2,122	...
Children,		...	...	3,261
7. Husbands in the army or navy—				
Wives,		...	1,435	...
Children,		...	...	3,407
8. Single women without children,		...	5,267	...
9. Want of work and other causes,		869	...	...
10. Sudden and urgent necessity,		117	...	...
		24,478	83,109	196,180

"4*th*, To mistresses, and the female sex in general, whether of high or low degree, we must look for great aid in this work of reform.

"We must now return to our second head,—namely, the loss of male life.

"I have already shown you the diseases of which men die in greater proportion than women. These are—congenital diseases, atrophy, debility, kidney disease, delirium tremens, apoplexy, paralysis, convulsions, and diseases of the brain, bronchitis, pleurisy, pneumonia, asthma, accident, suicide, and a long list of others, most of them arising from a depraved constitution and exposure, aggravated in many instances by bad habits, and transmitted, through the effects of such habits, by the male to his male children, whose conformation render them, I understand from medical men, more susceptible of disease in infancy. If man would reflect that his diseases, and I may add his habits and their constitutional effects, may be transmitted through many generations, he would surely

pause in his career, for such constitutional effects are greatly the causes of the great mortality in early life. This mortality in Great Britain, and in all countries where it obtains, is a national sin, and to it the attention of philanthropists, and all men anxious to benefit their race, should be directed.

"I have not touched on sanitary defects, as they apply to both male and female, but to that point also attention is urgently required.

"The drain upon the country by foreign wars is not to be forgotten among other causes which consume our male population. War, I am afraid, we must acknowledge as a necessity, but if that were the only drain upon our resources, we could, by the natural law of birth, meet it; and may it not be said that the greater number of male children born than female is to meet the decrement arising from accident and war.

"But to revert to the original statements with which I started:—

"In Scotland, at last census, there were

1,614,269 females
and 1,446,982 males

167,287 excess of females.

An army of male lives has thus disappeared, without taking into account the difference of 5 per cent. with which the males originally started.

"In England and Wales, at last census, there were

10,302,873 females
and 9,758,852 males

551,021 excess of females.

Upwards of half a million males lost, without taking into account the original 5 per cent in favour of male life.

"These two differences show what we have thrown away by premature death among males, and what we have lost by emigration, allowing 5 per cent. to stand for casualties to which men are exposed by war and otherwise. A lamentable conclusion, and particularly so as regards Scotland.

4. On the Danger of Hasty Generalisation in Geology. By Alexander Bryson, Esq.

5. On the Deflection of the Plummet caused by the Sun's and Moon's Attraction. By Edward Sang.

In this paper it was shown that the attraction of the sun causes a deflection of the plummet, having its maximum about the 240th part of a second, and proportional to the size of twice the sun's zenith distance; the deflection is at its maximum when the sun is 45° above or below the horizon, and occurs in the vertical plane passing through the attracting body.

The deflection due to the moon has its maximum about the 60th part of a second, and follows the same law; it is toward or from the attracting body according as the zenith distance is less or more than 90°.

Upon the cross-level of a transit instrument, the joint effect is to cause a semi-diurnal oscillation small at the quarters and rising to the 24th part of a second at new and full moon; while the influence upon meridian observations is sufficient to cause a disagreement between the greatest inclination of the moon's orbit, as observed at St Petersburg and Madras, amounting to the 50th of a second.

The general conclusion drawn was, that we cannot determine the positions of the heavenly bodies true to the 100th part of a second without having made allowance for this source of disturbance.

6. Note on Gravity and Cohesion. By Professor William Thomson.

The view, founded on Boscovich's theory, commonly taken of cohesion, whether of solids or of liquids, is, that it results from a force of attraction between the particles of matter, which increases much more rapidly than according to the inverse square of the distance, when the distance is diminished below some very small limit. This view might, indeed, seem inevitable, unless the idea of "attraction" is to be discarded altogether; because the law of attraction at sensible distances—the Newtonian law—demonstrated by its discoverer for distances not incomparably smaller than the earth's dimensions, and verified by Maskelyne and Cavendish in a manner rendering it impossible for any naturalist to reasonably doubt its applicability

to the mutual action between particles a few hundred yards or a few inches asunder, seems to give only very small, scarcely appreciable, forces between bodies of such masses as those we experiment on in our laboratories, everywhere placed as close as possible to one another,—that is to say, in contact, and does not seem to provide for any considerable increase of attraction when the area of contact is increased, whether by pressing the bodies together, or by shaping them to fit over a large area.

But if we take into account the heterogeneous distribution of density essential to any molecular theory of matter, we readily see that it alone is sufficient to intensify the force of gravitation between two bodies placed extremely close to one another, or between two parts of one body, and therefore that cohesion may be accounted for without assuming any other force than that of gravitation, or any other law than the Newtonian. To prove this, let two homogeneous cubes be placed with one side of each in perfect contact with one side of the other; and let one-third of the matter of each cube be condensed into a very great number, i, of square bars perpendicular to the common face of the two; and let the other two-thirds of the matter be removed for the present. The mass of each bar will be $\frac{1}{3i}$ of the whole mass originally given in each cube.

Let us farther suppose that the two groups of bars are placed so that each bar of one group has an end in complete contact with an end of a bar of the other. The attraction between each two such conterminous bars, however small their masses are, may be increased without limit, by diminishing the area of its section, and keeping its mass constant. But the whole mutual attraction between the two groups exceeds i times the attraction between each of the conterminous pairs, and may therefore be made to have any value, however great, merely by condensing each bar in its transverse section, and keeping their number and the mass of each constant.

We may now suppose another third of the whole mass to be condensed into bars parallel to another side of the cube, and the remaining third into bars parallel to the remaining side. If, then, either of these cubes be placed with any side in contact with any side of the other, and allowed to take the relative position to which it will obviously tend—that in which the bars perpendicular to the

common side of the two cubes come together end to end, there will be produced, by pure gravitation, a force of attraction between them which may be of any amount, however great, and which will be greater, the greater the ratio of the whole space unoccupied within the boundary of either cube, to the space occupied by the matter of the bars.

This illustration has been chosen merely for the sake of definiteness and simplicity; but it is clear that any arrangement, however complex, of woven fibrous structure, provided only the ratio of the unoccupied to the occupied space is sufficiently great, will lead to the same general conclusion. Farther, it is clear that the same result would be produced by any sufficiently intense heterogeneousness of structure whatever, provided only some appreciable proportion of the whole mass is so condensed in a continuous space in the interior that it is possible, from any point of this space as centre, to describe a spherical surface which shall contain a very much greater amount of matter than the proportion of the whole matter of the body which would correspond to its volume. Except in imposing this condition, the theory now suggested interferes with no molecular hypothesis hitherto propounded, continuous or atomic, finite atoms, or centres of force, static or kinetic.

Physical science abounds with evidence that there is an ultimate very intense heterogeneousness in the constitution of matter. All that is valid of the unfortunately so-called "atomic" theory of chemistry seems to be an assumption of such heterogeneousness in explaining the combination of substances. This alone, it is true, does not explain the law of definite combining proportions; but neither does the hypothesis of infinitely strong finite pieces of matter; and whatever is assumed to be the structural character of a chemical compound, a dynamical law of affinity between the two substances, according to the proportions of them lying or moving beside one another, must be added to do what some writers seem to suppose done by their "atomic theory."

It is satisfactory to find that, so far as cohesion is concerned, no other force than that of gravitation need be assumed.

The following Donations to the Library were announced:—

On Binocular Vision and the Stereoscope: a Lecture by William B. Carpenter, M.D., &c. 12mo.—*From the Author.*

Description of a New Species of Clerodendron from Old Calabar, which flowered in 1861 in the Royal Botanic Garden of Edinburgh. By John Hutton Balfour, A.M., M.D., &c. 8vo. —*From the Author.*

Abstract of the Proceedings of the Geological Society of London, Nos. 78, 79, 80.—*From the Society.*

Man and his Helpmate. By William Thomas Thomson. Folio. *From the Author.*

Monthly Return of the Births, Deaths, and Marriages Registered in the Eight Principal Towns of Scotland. March 1862. 8vo. —*From the Registrar-General.*

Monthly Notices of the Royal Astronomical Society. Vol. XXII. No. 5. 8vo.—*From the Society.*

Journal of the Chemical Society. No. LX. 8vo.—*From the Society.*

Monday, 28th April 1862.

PROFESSOR CHRISTISON, V.P., in the Chair.

The following Communications were read:—

1. Experimental Inquiry into the Laws of the Conduction of Heat in Bars, and into the Conducting Power of Wrought Iron. By Principal Forbes.

The experiments described in this paper were all made in 1850 and 1851, upon a plan which was fully explained by the author in letters to Mr Airy and Professor Kelland in the former year. Some notice of them appeared in the British Association Reports for 1851 and 1852, and the apparatus was supplied by a grant from the Association.

In previous inquiries into the thermal condition of a long conducting bar heated at one end, two assumptions have always been made: *First*, that the flux of heat across any transverse section of the bar is proportional throughout to the rapidity of the decrement of temperature reckoned along the axis of the bar (or to $\frac{dv}{dx}$, where v represents the temperature, above that of surrounding space, of any

point of the axis of the bar at a distance x from the origin). *Secondly*, That the loss of heat by radiation and convection from the surface of the bar is at every point proportional to the same temperature v. By assuming these principles (the last of which is certainly more or less inexact), the well-known solution of the problem of the heated bar is, that the temperatures (or excesses of temperature) diminish in a geometrical progression from the origin, and finally, of course, become insensible. Previous experimenters have confined themselves to finding the constants of the logarithmic curve for different substances, and thence their *relative* (not absolute) conducting powers.

In the experiments now described, neither of the above-mentioned principles is assumed. The external loss of heat is *directly* ascertained by experiment, and the admissibility or otherwise of the former principle is also *directly* tested. That principle may be thus symbolised: $F = -k\frac{dv}{dx}$, where F is the flux of heat across unit of section, k the conducting power for the substance employed, and v and x have the same signification as before.

I. In the first instance, a bar of iron 8 feet long and $1\frac{1}{4}$ inch in diameter, was heated by means of a crucible at one end, containing melted solder. Thermometers were inserted at various points of its length. The results, v in terms of x, were projected in a curve (approximately a logarithmic), and the values of $\frac{dv}{dx}$ were found by projection or calculation, or both.

II. Next a short bar (20 inches long), perfectly similar in section and condition of surface to the long bar, is heated to above 200° Cent. in a bath of fusible metal, and allowed to cool in free space, a thermometer being inserted at the centre of its length. This gives us the *rate at which such a bar is parting with its heat from all causes whatever*, in terms of the temperature shown by a thermometer in its axis.

III. The losses of heat in unit of time (one minute) last found may be taken as representing the amount of heat dissipated from each point of the long bar in the statical experiment (I.), being given in terms of the temperature proper to each point of such a bar. A curve may thus be constructed, having for its line of ab-

scissæ the axis of the long bar, and for ordinates, the rate of dissipation of heat from each portion of its surface due to both radiation and convection.

IV. If we can by mechanical quadrature, or otherwise, find the whole amount of heat dissipated between any point of the long bar and its coolest extremity, we have, in truth, the flux of heat passing from the hotter extremity of the body across the particular section in question; for the condition of permanence of the temperature of the bar arises from the equality of the heat supplied and dissipated. But the whole heat dissipated in unit of time is the integral of the partial dissipations represented by vertical ordinates of the last-named curve, taken between any assumed point x and the farthest or cool end of the bar. This quantity, then, is F or the flux across unit of section at the point x.

V. We are now able to resolve the question whether or not the flux of heat is in the given bar everywhere proportional to the rapidity with which the temperature decreases as x increases, or whether the equation holds, $F = -k\frac{dv}{dx}$, the conducting power k being supposed to be constant.

The following table (the result of an *approximate* reduction made in 1852) shows that the constancy of k in the case of iron cannot be assumed; on the contrary, that the conductivity diminishes as the temperature increases. The first column is the observed temperature of given points of the bars; the second and third columns give the values of k from the preceding equation—(1.) as deduced from experiments on the iron bar with a polished surface; (2.) when the surface was covered with thin paper. The general coincidence of the two is satisfactory, since the external cooling was considerably different in the two cases.

Actual Temperature, Centigrade.	$\frac{F}{-\frac{dv}{dx}}$; polished bar.	$\frac{F}{-\frac{dv}{dx}}$; covered bar.
25°	·0136	·0147
50	·0130	·0138
75	·0131	·0123
100	·0126	·0113
125	·0122	·0107
150	·0112	·0107
175	·0100	·0102
200	·0087	...

The mean of both series may be tolerably represented by a uniformly diminishing conductivity as the temperature increases. When reduced* to the usual units of conducting power expressed in terms of the amount of heat necessary to raise by 1° Centigrade a cubic foot or a cubic centimètre (one gramme) of water respectively, we have the following absolute measures :—

Temperature, Centigrade.	Conducting Power of Wrought Iron. Units, the Foot, Minute, and Cent. Degree.	Units, the Centimètre, Minute and Cent. Degree.
0°	·0133	12·36
50	·0120	11·15
100	·0107	9·94
150	·0094	8·73
200	·0082	7·62

It is to be observed that thermometric readings have not yet been finally corrected, so that these numbers may receive some slight modification. The author hopes to complete the verification of the calculations, so far as wrought iron is concerned, in the course of the present summer. The state of his health has been the cause, not only of the suspension of the experiments, but of the long delay which has taken place in publishing the results so far as obtained.

2. On Certain Vegetable Formations in Calcareous Spar. By Principal Sir David Brewster.

3. On the Existence of *Acari* between the Laminæ of Mica in Optical Contact. By Principal Sir David Brewster.

4. On the Secular Cooling of the Earth. By Professor William Thomson.

The fact that the temperature of the earth increases with the depth below the surface, implies a continual loss of heat from the interior by conduction outwards, through or into the upper crust. Since the upper crust does not become hotter from year to year, there must therefore be a secular loss of heat from the whole earth. It is possible that no cooling may result from this loss of heat, but

* The numbers in the preceding table refer to the thermal capacity of iron instead of water.

only exhaustion of potential energy, which in this case could scarcely be other than chemical affinity between substances forming part of the earth's mass. But it is certain that either the earth is becoming, on the whole, cooler from age to age, or that the heat conducted out is generated in the interior by temporary dynamical action (such as chemical combination). To suppose, as Lyell has done,* that the substances combining together, according to the chemical hypothesis of terrestrial heat, may be again separated electrolytically by thermo-electric currents due to the heat generated by their combination, and thus the chemical action and its heat continued in an endless cycle, violates the first principles of natural philosophy in exactly the same manner and to the same degree, as to believe that a clock constructed with a self-winding movement may fulfil the expectations of its ingenious inventor by going for ever.

Adopting as the more probable, the simpler hypothesis that the earth is merely a heated body cooling, and not, on the whole, influenced to any sensible degree by interior chemical action, the author applies Fourier's theory of the conduction of heat to trace the earth's thermal history backwards. From data regarding the specific heat and thermal conductivity of the earth's substance, he investigates the time that must elapse from an epoch of any given uniform high temperature throughout the interior, until the present condition of underground temperature could be reached. Taking into account the very uncertain character of the data when high temperatures are concerned, he infers that most probably either the whole earth must have been incandescent at some time from 50,000,000 to 500,000,000 years ago, or that at some less ancient date, but still anterior to the earliest human history, there must have been up to the surface a temperature above the boiling-point of water. Either alternative—or indeed any theory whatever consistent with the principles of natural philosophy regarding previous conditions of the earth—is as decisive against the views of those naturalists who acknowledge no creation of life on the earth within fathomable periods of time, as the plainest elements of dynamics are against those who maintain that we have no evidence in nature of an end.

* Principles of Geology.

5. Notice of the Ravages of the *Limnoria Terebrans* on Creosoted Timber. By David Stevenson, Esq., F.R.S.E., M.I.C.E., &c.

The author stated that it would be difficult to estimate the value of any chemical or mechanical process whereby timber might be rendered permanently impervious to the ravages of the *Limnoria terebrans*, that small but sure destroyer of timber structures exposed to the action of the sea.

The ravages of that crustacean were first observed in 1810 by Mr Robert Stevenson, the engineer of the Bell Rock Lighthouse, in the timber supports of the temporary beacon used by him in the erection of that work. Having forwarded specimens of the insect, and of the timber it had destroyed, to Dr Leach, the eminent Naturalist of the British Museum, Dr Leach, in 1811, announced it as a "new and highly interesting species which had been sent to him by his friend Robert Stevenson, civil engineer," and assigned to it the name of *Limnoria terebrans* (Linnean Trans., vol. xi. p. 370, and Edinburgh Encyclopædia, vol. vii. p. 433).

The *Teredo navalis*, which was a larger and even more destructive enemy, was happily not so prevalent in northern seas as the Limnoria.

Experiments made at the Bell Rock by Mr Robert Stevenson, extending over a period of nearly thirty years, the detailed account of which was given in Mr Thomas Stevenson's article on Harbours in the "Encyclopædia Britannica," had clearly proved that teak, African oak, English and American oak, mahogany, beech, ash, elm, and the different varieties of pine, were found sooner or later to become a prey to the Limnoria. Greenheart oak was alone found to withstand their attacks; and even this timber was said in some instances to have failed.

Mr Stevenson's experiments also included the testing of the artificial processes of Kyan and Payne, the former being an injection of corrosive sublimate, and the latter of proto-sulphate of iron. Timber prepared by Kyan's process was attacked in two years and four months, and in four years and seven months was quite destroyed. Timber prepared by Payne's process was attacked in ten months, and destroyed in one year and ten months.

The justly approved creosote process, patented by Mr Bethell, had been largely employed in railway works, with universally admitted success, and, in common with many of his professional brethren, the author adopted it in several marine works, in the expectation that it would prove an antidote to the Limnoria; but having now ascertained beyond all doubt that creosote was not a universal or permanent preservative of timber used in marine works, the author proposed, in the present notice, to state briefly the facts on which this opinion was grounded.

Before doing so, however, he wished it to be distinctly understood that he did not undervalue Mr Bethell's highly important invention as a preservative of timber against all ordinary decay incident to railway sleepers, timber viaducts, and, indeed, all timber structures not exposed to sea-water infested with the *Limnoria terebrans*. His remarks referred exclusively to its application for marine works below half-tide level. For all other classes of works, he believed it to be a most valuable preservative.

In 1859, in a discussion which followed a paper on the "Permanent Way of the Madras Railway," at the Institution of Civil Engineers, the author first stated that there were distinct evidences of the attack of the *Limnoria terebrans* on creosoted timber used at Scrabster Harbour in Caithness; while Mr Bethell, the patentee, and others, expressed their conviction that creosoted timber could not be perforated by any worm or insect.

Subsequent experience and observation have satisfied the author that the statement which he then made was correct, the fact, as now ascertained, being that thoroughly creosoted timber is, in certain situations, readily perforated by the Limnoria Terebrans.

The first instance to which he referred was the pier at Leith, which was executed about 1850, by the late Mr Rendel. The whole of the timber employed was creosoted on the spot in the most careful manner. As the piers at Leith were washed by a constant admixture of fresh water from the water of Leith, the author expected that the progress of devastation at that place would be so slow as to be hardly appreciable on creosoted timber. But having carefully examined the West Pier, he corroborated the evidence given by Mr A. M. Rendel in 1860, before the Select Committee on Leith Docks' Bill, that, notwithstanding the most careful application of creosote, the timber work has been attacked by the insect to a great extent.

The second case to which he referred was Invergordon. Two steamboat jetties were constructed at that place from designs by Messrs Stevenson. It was generally represented that there were little or no traces of marine insects in the Cromarty Frith, and it was resolved that it was a situation peculiarly suitable for employing timber pile-work protected by creosote. The timber used in the work was carefully selected at Leith, and dressed to the necessary scantlings and lengths, so as to avoid all cutting after it had undergone the process of creosoting. It was then creosoted by an agent sent by Mr Bethell for the purpose, at the sight of a careful inspector employed by the engineers. Every piece of timber was weighed before being put into the tank, and the process of creosoting was continued until each piece had received, as nearly as possible, the specified quantity of 10 lbs. of oil per cubic foot. Some experimental pieces were from time to time cut longitudinally, when it was found that the creosote had entered the ends of the logs 18 inches to 2 feet, and that it had saturated the timber some two or more inches all round. No greater precautions could possibly be used to insure perfection in carrying out the process, which involved an additional cost of about L.450. The jetties were erected in 1858, and now the Superintendent's report was, "that the blackened or creosoted portion of the timber is very much eaten and perforated. The timber perforated is just as it came from the creosoting tank, never having been cut. There is $1\frac{1}{4}$ inch wasted on some of the piles that have been perforated."

The third case to which he referred was Scrabster, which was also constructed under Messrs Stevenson's directions. The timber employed in this instance was selected Memel of first-rate quality; it was carefully creosoted at Glasgow. On cutting up a timber that had been attacked by the Limnoria, it was found that the creosote had fully entered at the ends, and saturated the sides, and yet it was discovered to have been attacked after it had only been exposed thirteen months,—the insect perforating the blackened timber. The whole of the creosoted portion of the timber work was now more or less worm-eaten and destroyed. Mr Leslie had also directed the author's attention to similar results at Granton and Stranraer, at both of which places the creosoted timber had been perforated.

The author held that these instances were enough to prove that the failure was not peculiar to one spot or one isolated case. If it

was said that the timber used at these places had not been *properly* creosoted, it might fairly be concluded, that if the process, even when conducted in the patentee's own works, to the satisfaction of careful inspectors, was so difficult and uncertain in its results, its general applicability would be greatly injured. All newly creosoted timber, whether it was well or ill done, presented the same appearance externally; and it was only by weight that the completeness of the saturation could be judged of; and if careful weighing before and after the timber had been creosoted was not to be held as an ample and satisfactory test that the process had been properly conducted, it seemed hopeless to expect that perfect satisfaction could be attained. But it was so far fortunate for Mr Bethell's system, that it was not needful in the cases to which allusion had been made to call in question the extent of saturation which his process secured when properly executed. The timber at Scrabster and Invergordon, and he believed at the other places named, was undoubtedly thoroughly and properly saturated, and the author said that the explanation of the failure was to be found in the fact, that the Limnoria *perforated timber which had been thoroughly creosoted and blackened*—a fact which at once disproved the assumption, hitherto so generally made, that the poisonous nature of the creosote would prevent the insect from attacking it. As the Pholas perforated stone to procure shelter, the Limnoria might excavate timber for the same purpose, and obtain its food from the minute animalculæ with which the water of the ocean was charged. Dr Coldstream, in his elaborate paper on the Limnoria in the "Edinburgh New Philosophical Journal" for April 1834, had concluded that the Limnoria fed on the timber, and not on animal substances; but even if this were so, there seemed no reason to conclude that creosoted timber could not be eaten by insects, on account of the poisonous nature of the preparation employed. The author stated, that it had been ascertained that there were insects that lived and fattened on food that was to man a deadly poison. In the "British Medical Journal" for April 1862, there was an interesting notice on the subject. Mr Attfield had there shown that substances which are intensely poisonous to the higher animals do not affect *Acari*, which he found not only readily ate, but actually fattened on, strychnine, morphine, and other deadly poisons. But the author stated that the specimens which he laid before the Society proved conclusively that creosote

does not act as a poison in preserving the timber, because it could be seen that the Limnoria were embedded in wood still highly charged with creosote.

After carefully considering the subject, the author had no doubt that the process of creosoting preserved timber from the attack of marine insects only so long as the oil existed as a film or coating on the outside of the timber. Whenever the attrition caused by the motion of the sea removed this outer film or coating, and exposed the fibrous surface of the timber, the insect would then attack and perforate it, whether it were creosoted or not, its search being for a fibrous substance in which to burrow. The time that might elapse before the timber became assailable to these insects depended on the situation. Wherever there was little abrading action of the sea, the exterior film of creosote might be longer preserved; and where there was a considerable admixture of fresh water to check the growth, or at least the avidity of the insect, the effect of their ravages might be more gradual, or, in some situations, almost inappreciable. But the result of the author's observation and experience led him irresistibly to the conclusion, that on the northern shores of the country, where works are exposed to the open sea, creosoted timber was readily perforated by the Limnoria, and could not be safely employed in any important part of a marine structure at or below half-tide level, a fact of great importance to the civil engineer.

6. On some Thermic Properties of Water and Steam. By Professor W. J. Macquorn Rankine.

The author refers to the general equation of the mechanical action of heat which Professor Clausius and he arrived at independently by different methods in 1849, and points out that the form of that equation, which was laid before the Society by him in a paper read on the 4th of February 1850, comprehends, as a particular case, the law which connects the volume of a given weight of steam with its temperature, pressure, and latent heat. He describes the use of that law, with proper numerical data, to compute, in the absence of direct experiment, tables of the density and volume of saturated steam, more accurate than those founded on the assumption of the perfectly gaseous condition, as exemplified in tables which he pub-

lished in 1855 and subsequently. Referring next to the direct experiments of Messrs Fairbairn and Tate on the density of steam, published in the Philosophical Transactions for 1860, he gives a tabular comparison of the volumes of one pound of steam as determined by these experiments, and as computed theoretically from M. Regnault's experiments on the latent heat of steam, with the aid of Joule's mechanical equivalent of heat; and from that comparison he draws conclusions which may be summed up as follows:—

1. At temperatures below 212°, the differences between the results of theory and experiment are inappreciable.

2. At temperatures above 212°, the differences, although too small to be of any consequence in practical calculations connected with steam-engines, are appreciable, the volume of a pound of steam by theory being slightly greater than by experiment.

3. Small as those differences are, there exist no known sources of error either in the data of the theoretical calculation or in the method of experimenting sufficient to account for them.

4. They are therefore most probably caused by some unknown difference in the molecular condition of the steam in M. Regnault's experiments on latent heat, and in Messrs Fairbairn and Tate's experiments on density.

5. That difference of condition is probably connected with the fact, that in M. Regnault's experiments the steam was in rapid motion from a boiler towards a condenser; whereas in the experiments of Messrs Fairbairn and Tate the steam was at rest.

6. Further experimental researches are desirable.

7. Formulæ connected with small continuous Displacements of the Particles of a Medium. By Professor Tait.

Although most of the results deduced in this Note have been long known, I venture to offer it to the Society on account of the extreme simplicity of the analysis employed, and the consequent insight it affords us into the connection of various formulæ. I intend on a future occasion to give large further developments especially bearing on physics. I employ the calculus of quaternions throughout, but where some unusual expressions occur, I have given them in their common Cartesian form, as well as in the quaternion one.

I. $$\text{If } F\varrho = C \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

be the equation to one of a system of surfaces, and if the differential of (1) be

$$S.\nu d\varrho = 0 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2),$$

ν is a vector perpendicular to the surface, and its length is inversely proportional to the normal distance between two consecutive surfaces. In fact (2) shows that ν is perpendicular to $d\varrho$, which is any tangent vector, thus proving the first assertion. Also, since in passing to a proximate surface we may write

$$S.\nu\delta\varrho = \delta C, \text{ we see that}$$
$$F(\varrho + \nu^{-1}\delta C) = C + \delta C.$$

This proves the latter assertion.

It is evident from the above that if (1) be an equipotential, or an isothermal, surface, $-\nu$ represents in direction and magnitude the force at any point or the flux of heat. And we see at once that if

$$\triangleleft = i\frac{d}{dx} + j\frac{d}{dy} + k\frac{d}{dz} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3),$$

giving $$\triangleleft^2 = -\frac{d^2}{dx^2} - \frac{d^2}{dy^2} - \frac{d^2}{dz^2} \quad . \quad . \quad . \quad . \quad . \quad (3)^1,$$

$$\text{then } \nu = \triangleleft F\varrho. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4).$$

This is due to Sir W. R. Hamilton (*Lectures on Quaternions*, p. 611).

From this it follows that *the effect of the vector operation $\triangleleft$ upon any scalar function of the vector of a point is to produce the vector which represents in magnitude and direction the most rapid change in the value of the function.*

Let us next consider the effect of $\triangleleft$ upon a *vector* as

$$\sigma = i\xi + j\eta + k\zeta \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (5).$$

We have at once

$$\triangleleft\sigma = -\left(\frac{d\xi}{dx} + \frac{d\eta}{dy} + \frac{d\zeta}{dz}\right) - i\left(\frac{d\eta}{dz} - \frac{d\zeta}{dy}\right) - \&c. \quad . \quad (6),$$

and in this semi-Cartesian form it is easy to see that—

If σ represent a small vector displacement of a point situated at the extremity of the vector ϱ (drawn from the origin)

S . ◁ σ *represents the consequent cubical compression of the group of points in the vicinity of that considered, and*

V . ◁ σ *represents twice the vector axis of rotation of the same group of points.*

Similarly

$$S.\sigma\triangleleft = -\left(\xi\frac{d}{dx}+\eta\frac{d}{dy}+\zeta\frac{d}{dz}\right) = -D_\sigma \quad . \quad . \quad (7),$$

or *is equivalent to total differentiation in virtue of our having passed from one end to the other of the vector* σ.

The interpretation of V . σ◁ is also easy enough, but it is not required for the present investigation.

II. Suppose we fix our attention upon a group of points which originally filled a small sphere about the extremity of ϱ as centre, whose equation referred to that point is

$$T\omega = e \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (8).$$

After displacement ϱ becomes ϱ + σ, and by (7) ϱ + ω becomes ϱ + ω + σ − (S . ω◁)σ. Hence the vector of the new surface which encloses the group of points (drawn from the extremity of ϱ + σ), is

$$\omega_1 = \omega - (S.\omega\triangleleft)\sigma \quad . \quad . \quad . \quad . \quad . \quad . \quad (9).$$

Hence ω is a homogeneous linear and vector function of ω_1; or

$$\omega = \varphi\omega_1$$

in Sir W. R. Hamilton's notation, and therefore by (8)

$$T\varphi\omega_1 = e \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (10),$$

the equation to *the new surface, which is evidently a central surface of the second order, and therefore, of course, an ellipsoid* (Cauchy—*Exercises*, vol. ii.).

We may solve (9) with great ease by approximation, if we remember that Tσ is very small, and therefore that in the small term we may put ω_1 for ω—*i.e.* omit squares of small quantities; thus,

$$\omega = \omega_1 + (S.\omega_1\triangleleft)\sigma \quad . \quad . \quad . \quad . \quad . \quad . \quad (11).$$

Or if we choose we may obtain the exact solution very easily. Operating on (9) with S . *i*, S . *j*, S . *k*, we get

$$Si\omega_1 = S\omega'i + \triangleleft\xi), \text{ \&c.} = \text{\&c.}$$

Hence

$$\omega\,\mathrm{S}.(i+\triangleleft\xi)(j+\triangleleft\eta)(k+\triangleleft\zeta)=\mathrm{V}.(j+\triangleleft\eta)(k+\triangleleft\zeta)\mathrm{S}i\omega_1+\&c.$$

From this we may easily verify the former expression by omitting products of ξ, η, ζ.

Thus $$\omega(-1-h)=\left[i(1+h)-\frac{d\sigma}{dx}\right]\mathrm{S}i\omega_1+\&c.+\&c.,$$

where $$h=\frac{d\xi}{dx}+\frac{d\eta}{dy}+\frac{d\zeta}{dz}.$$

Or $$\omega=-(i\mathrm{S}i\omega_1+\&c.)+(\mathrm{S}.\omega_1 i)\frac{d\sigma}{dx}+\&c.$$

$$=\omega_1+(\mathrm{S}.\omega_1\triangleleft)\sigma \text{ as before,} \quad . \quad . \quad . \quad (11).$$

Thus it appears that the equation to the ellipsoid may be written

$$\mathrm{T}\left(\omega+(\mathrm{S}\omega\triangleleft)\sigma\right)=e \quad . \quad . \quad . \quad . \quad . \quad . \quad (10).$$

III. The differential of this equation is

$$\mathrm{S}\left(\omega+(\mathrm{S}\omega\triangleleft)\sigma\right)\left(d\omega+(\mathrm{S}d\omega\triangleleft)\sigma\right)=0,$$

whence, omitting the second order of small quantities, the normal vector is

$$\omega+(\mathrm{S}\omega\triangleleft)\sigma+\triangleleft\,\mathrm{S}\omega\sigma.$$

To find the axes we must therefore express that the latter is parallel to ω, or

$$p\omega=(\mathrm{S}\omega\triangleleft)\sigma+\triangleleft\,\mathrm{S}\omega\sigma \quad . \quad . \quad . \quad . \quad . \quad (12).$$

where p is an undetermined scalar.

The most obvious method of solving this equation is to operate in succession by $\mathrm{S}.i$, $\mathrm{S}.j$, and $\mathrm{S}.k$. We thus obtain,

$$p\mathrm{S}i\omega=\mathrm{S}\omega\triangleleft\,\mathrm{S}i\sigma+\mathrm{S}i\triangleleft\,\mathrm{S}\omega\sigma$$

$$\&c.=\&c.$$

Or, remembering (5),

$$\mathrm{S}.\omega\left(pi+\triangleleft\xi+\frac{d\sigma}{dx}\right)=0,$$

$$\&c. \qquad =0,$$

p is therefore a root of the equation

$$\mathrm{S}.\left(pi+\triangleleft\xi+\frac{d\sigma}{dx}\right)\left(pj+\triangleleft\eta+\frac{d\sigma}{dy}\right)\left(pk+\triangleleft\zeta+\frac{d\sigma}{dz}\right)=0.$$

or, as it may evidently be written,

$$\begin{vmatrix} p+2\frac{d\xi}{dx} & \frac{d\xi}{dy}+\frac{d\eta}{dx} & \frac{d\xi}{dz}+\frac{d\zeta}{dx} \\ \frac{d\xi}{dy}+\frac{d\eta}{dx} & p+2\frac{d\eta}{dy} & \frac{d\eta}{dz}+\frac{d\zeta}{dy} \\ \frac{d\xi}{dz}+\frac{d\zeta}{dx} & \frac{d\eta}{dz}+\frac{d\zeta}{dy} & p+2\frac{d\zeta}{dz} \end{vmatrix}=0. \quad . \quad (13).$$

A value of p having been found from (13), the direction of the corresponding axis is given by

$$\omega \parallel \mathrm{V}.\left(pi+\triangleleft\xi+\frac{d\sigma}{dx}\right)\left(pj+\triangleleft\eta+\frac{d\sigma}{dy}\right) \quad . \quad . \quad (14).$$

III. *a.* As a very simple example of distortion, suppose ϱ to represent the position of each particle with regard to a centre attracting according to Newton's law, and let σ the vector of distortion be a small constant multiple of the vector force. Then

$$\frac{m}{\mathrm{T}\varrho}=\mathrm{C}\text{ (the potential).}$$

$$\text{Hence } \sigma=\frac{gm\varrho}{\mathrm{T}\varrho^3}, \text{ where } g \text{ is very small,}$$

$\therefore$ when ϱ becomes $\varrho+\sigma$, $\varrho+\omega$ becomes $\varrho+\omega+\frac{gm(\varrho+\omega)}{\mathrm{T}(\varrho+\omega)^3}$. As $\mathrm{T}\omega$ is exceedingly small, this may be written

$$\varrho+\omega+\frac{gm(\varrho+\omega)}{\mathrm{T}\varrho^3\left(1-3\frac{\mathrm{S}\omega\varrho}{\mathrm{T}\varrho^2}\right)}.$$

Hence $\omega_1=\omega+\frac{gm}{\mathrm{T}\varrho^3}\left(\omega+3\varrho\frac{\mathrm{S}\omega\varrho}{\mathrm{T}\varrho^2}\right)$, and an originally spherical surface $\mathrm{T}\omega=e$ (8) becomes after distortion approximately

$$\mathrm{T}\left(\omega_1-\frac{gm}{\mathrm{T}\varrho^3}(\omega_1+3\varrho\frac{\mathrm{S}\omega_1\varrho}{\mathrm{T}\varrho^2})\right)=e,$$

a spheroid of revolution whose axis is ϱ, as indeed is evident.

IV. In this latter case we see at once that $\mathrm{V}.\triangleleft\sigma=0$, and it is easy to show that in general, *if the small displacement of each point of a medium is in the direction of, and proportional to, the*

attraction exerted at that point by any system of masses, the displacement is effected without rotation. For if $\mathrm{F}\varrho = \mathrm{C}$ be the potential surface, we have $\mathrm{S}\sigma d\varrho$ a complete differential—*i.e.*, in Cartesian co-ordinates $\xi dx + \eta dy + \zeta dz$ is a differential of three independent variables. Hence the vector axis of rotation $i\left(\frac{d\zeta}{dy} - \frac{d\eta}{dz}\right)$ + &c., vanishes by the vanishing of each of its constituents, or $\mathrm{V}.\nabla\sigma = 0$.

Conversely, *if there be no rotation the displacements are in the direction of, and proportional to, the normal vectors to a series of surfaces.*

For

$$0 = \mathrm{V}.d\varrho\mathrm{V}.\nabla\sigma = (\mathrm{S}d\varrho\nabla)\sigma - \nabla\mathrm{S}\sigma d\varrho.$$

Now, of the two terms on the right, the first is a complete differential, since it may be written $-\mathrm{D}_{d\varrho}\sigma$ (see (7)), and therefore the remaining term must be so.

Thus, in a distorted system, there is no compression if

$$\mathrm{S}.\nabla\sigma = 0,$$

and no rotation if $\mathrm{V}.\nabla\sigma = 0$; and evidently *merely transference if* $\sigma = \alpha = a$ *constant vector*, which is one case of $\nabla\sigma = 0$.

In the important case of $\sigma = e\nabla\mathrm{F}\varrho$ there is evidently no rotation, since $\nabla\sigma = e\nabla^2\mathrm{F}\varrho$ is evidently a scalar. In this case, then, there are only translation and compression, and the latter is at each point proportional to the density of a distribution of matter, which would give the potential $\mathrm{F}\varrho$. For if r be such density, we have at once $\nabla^2\mathrm{F}\varrho = 4\pi r$ (see $(3)^1$). This suggests a host of physical analogies which we cannot enter upon at present.

V. Keeping still to the meaning of σ as the vector of displacement, as we have seen that $\nabla\sigma = s + \imath$, where s is the condensation of the particles near the extremity of ϱ, and $\imath$ the doubled vector axis of rotation of the group—we may apply the vector operation a second time. Thus,

$$\nabla^2\sigma = \nabla s + \nabla\imath.$$

Now, our former results enable us to assign meanings to these expressions. ∇s is the normal-vector to any of the surfaces of equal condensation. The scalar and vector parts of $\nabla\imath$ represent

the compression, and the doubled-axis of the rotation, consequent on the displacement of each point through a space represented by ι. Also it is easy to see that $\triangleleft^2\sigma$ is a pure vector. Hence

$$S.\triangleleft V\triangleleft\sigma = 0.$$

If therefore there be two similar media, and the particles of one be slightly displaced in a continuous manner—the particles of the other being displaced through vectors proportional to the rotations at each point in the first mass—this displacement takes place without condensation.

And, as $V.\triangleleft\triangleleft s = 0$, we have the other result, that *if the particles of the second medium be displaced through vectors representing the direction and rate of most rapid change of compression in the first, such displacement will take place without rotation.* But this is merely another way of stating the first proposition in IV.—(Compare Thomson, "On a Mechanical Representation of Electric, Magnetic, and Galvanic Forces"—*Camb. and Dub. Math. Jour.*, vol. ii.; and Maxwell, "On Physical Lines of Force"—*Phil. Mag.*, 1861–62.)

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INDEX.

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CONTENTS.

[*Turn over.*

[*For continuation of Contents, see pp.* iii *and* iv *of Cover.*